POWER

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MR. EMPLOYER, have you been down into your engine room lately?

Do you know what the temperature is there these hot days?

Did it ever occur to you that the men who must live and work—do hard physical work—in that temperature, must suffer?

Think, the next time that you are sweltering and gasping because it is 90 deg. in your parlor car or library, of the poor fellows who work for you twelve hours or more every day in a cellar where it is 110 deg. or more.

You wouldn't condemn men—your men—to such discomfort unnecessarily, would you?

Have you done all that you can to better their condition? You cannot put the engine and boilers on the roof, but have you done what you can, in reason, to make the place where they must be, livable? Are the heat radiating surfaces covered as thoroughly as they might be? Are there ample ducts to supply cool fresh air? Are there means for taking off the air which has been heated by contact with and radiation from hot surfaces?

A few connections from the top of such a room to the ash pits and exhaust fan will pull out the heated air, reduce the temperature a number of degrees and increase the comfort in a greater proportion. A desk motor fan such as you use yourself would help some.

Drop down and see how your power plant men are standing the hot spell; how long you would stand it in their places; and what you can do to make it easier for them.

Prize Turbine Article

Running a Steam Turbine

By Paul Hoffman

In the last issue of 1911 POWER offered a prize of $50 in gold for the best article on the practical operation of a steam turbine. Of the 46 manuscripts received in response to this offer this was unanimously chosen by the judges as the best. Others of the articles, treating the operations more in detail and with illustrations, will be published in later issues.

The repeated call for contributions to the contest which the editors of POWER proposed to their subscribers, on running a steam turbine, encourages me, although rather a stranger to American practice and in no way proficient in English composition, to submit a few ideas on the subject.

My experience in operating steam turbines has been largely in Germany, where these engines are in high favor; as American types, however, do not differ in any essential feature from their European relatives, the following remarks will apply to them as well:

To begin with I must apologize for finding some fault with the statement of the question, as it was put before the readers of POWER: How can a man, *who never saw a turbine except in a picture book*, be led alongside such a machine and told how to run and to attend it?

Frankly, I would not like such a man to experiment with a turbine, and, in fact, I believe that, except in cases of emergency, this practice will not be followed by any turbine owner. Before taking charge of a turbine the novice engineer—although he may be a perfect reciprocating man, should be thoroughly instructed as to the necessary manipulations by the contractor's erecting man, if a new installation is concerned, or by his predecessor if he is to take care of an existing plant.

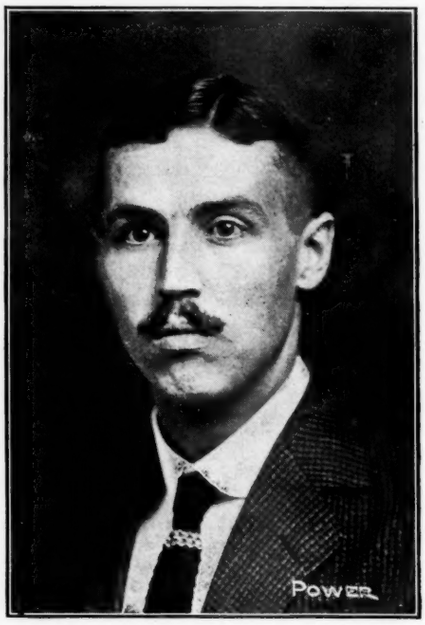
It would be of great assistance if every builder of turbines would furnish complete and definite instructions with each engine erected and give some practical lessons to the man who is to operate it. This policy has been adopted with excellent results in Germany; it does not yet seem to be general in this country. Do we ask too much if we want our new engineer to have also some inside information about his machine, and would it not be desirable that he had a certain knowledge of the fundamental principles of a turbine?

POWER itself has set a very high standard for the engineering profession. According to its views, and in order to be more than a mere stopper and starter, every uptodate turbine engineer should aspire to understand the theoretical side of his machine too. He should possess more than the fundamentals of heat and thermo-dynamics; he should know something about the conversion of pressure into velocity, and he ought to be acquainted with the ways of reaching a compromise between the tremendous velocity of spouting steam and the demands of the driven machinery, the methods of pressure- and velocity-staging and the combination of the two, the relation between speed and efficiency, and a dozen items more.

The means of knowledge are close at hand; a few good books and engineering journals will furnish the required theoretical information.

All his science, it has been objected, will entirely fail to make him a successful engineer. Science alone, indeed; for the most important part of engineering practice is empirical. But knowledge added to experience and observation will help a good deal to answer all the whys and wherefores which may be encountered in a turbine plant.

Now, the preceding considerations by no means imply that it takes a specially educated or experienced man to run a turbine, as long as everything goes right. On the contrary, the turbine builders have so successfully endeavored to simplify the task of attendance, to make everything mechanical, automatic and foolproof, that the job may seem easy. But, let any trouble arise, and the difference between the ignorance and lack of judgment of the mere engine-driver and the resourcefulness and competence of the "man who knows" will come into evidence. A turbine is a piece of fine machinery which should receive intelligent attention; the higher the class of machine the more this is true.



PAUL HOFFMAN

Paul Hoffman, the winner of the turbine article prize, was born in 1882. He has been engaged in engineering since the age of 17 and for about 8 years in steam turbine work. His theoretical training was at the Polytechnicum, Zurich, Switzerland, with Professor Stodola, and his practical experience was obtained in the shops of the Elsassische Maschinenbau, Mülhausen, Alsace; Escher-Wyss, Zurich, and in the German Navy.

For the last three years Mr. Hoffman has specialized in turbo-compressors and took part in the designing of the first Zoelly turbo-compressors.

He came to this country one year ago and is now with the Ingersoll-Rand Co., at Phillipsburg, New Jersey.

SMALL TURBINES

The turbines built and operated in this country vary largely in size and design. Their principal use, up to now, has been to generate electric power. In recent times the field for turbines, and for small turbines especially, has much enlarged; they have been applied as prime movers to all sorts of auxiliary machinery, to pumps, blowers, compressors. The small-capacity turbines used also for excitation service, for light and power purposes of small plants, up to about 200 kw., constitute a class by themselves. They are designed on different principles than the large units; simplicity, ruggedness and reliability are the factors first considered in their construction.

Built with a single wheel, of the pure impulse type, as in the De Laval turbines, or with velocity stages as in the Kerr, Terry, etc., turbines with the governor acting directly on the throttling valve, with all attached mechanism reduced to their simplest expression, have nothing to get out of order and their operation needs a minimum of care. A man looks at them once or twice a watch, and puts his hands on the bearings; oil is filled in once a month, and they keep

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running for years without interruption, without repairs, with practically no maintenance cost. This is the reason of their success, in spite of their lower efficiency, compared with reciprocating engines.

Large Turbines

From about 400 kw. upward, however, the turbine enters the competition with the reciprocating engine on a new basis, for it shows, with increasing capacity, an advantage in economy, which becomes quite conspicuous in the very large units installed in recent times in different power stations. Large turbines are built essentially on the principle of high efficiency and their design and mechanical construction is accordingly more elaborate and complicated.

The present remarks will apply to this class of turbines only, as requiring naturally a more careful attendance and being subject to more disturbances.

The three well known manufacturers of large turbines in the United States, the General Electric, Westinghouse and Allis-Chalmers companies, have developed two different types of turbines.

The General Electric turbine is an impulse turbine, with a reduced number of velocity-stage, or so-called Curtis wheels. The Westinghouse and Allis-Chalmers types are based upon the reaction principle (Parsons) with multiple pressure stages. Besides these, the impulse or action turbine with multiple pressure stages, as of the Rateau or Zoelly type, has been constructed, but is as yet of limited, though increasing importance.

Clearance

Without discussing the design of any of these turbines let us only point to a few features, common to all, which will particularly strike the converted reciprocating engineer. Among the conflicting stories which he may have heard about steam turbines, a special emphasis is laid on the tremendous speed of the rotating parts and great stress is put upon the disastrous effects of an encounter between blades traveling with a velocity nearly that of a cannon-ball, and any obstacle. A certain uneasiness on this behalf may seem warranted, for it must be conceded that, until recently, the clearances between moving and stationary blades were often made too small, so that the least vibration of the shaft would cause both parts to touch, often resulting in blades being torn off, and wheels and shaft distorted.

With regard to this point, impulse and reaction turbines show somewhat different requirements. Whereas the radial clearance in impulse turbines is practically unlimited and the axial distance can be made 0.1 to 0.2 of an inch and more without appreciable loss in efficiency, the reaction turbine demands reducing the radial clearances to the lowest practical amount. The blades need not run close together, but, to prevent excessive leakage over their tops, the distance between the ends of the moving blades and the casing and between the ends of the fixed blades and the rotor, must be kept down to 0.025 to 0.125 in., according to the size of the machine and the length of the blades. These figures demand evidently the highest grade of workmanship on the part of the builder and an accurate balancing of the rotor. The arrangement of the dummy rings on the balancing pistons adds to the difficulty. At this point, too, most careful adjustment is required. To prevent steam leakage to the condenser the projecting rings turned out in the rotor must run as closely as possible to the corresponding strips in the casing, the allowed clearance being about 0.01 of an inch.

The axial adjustment is controlled by the thrust bearing which can be moved in either direction by bolts acting on the casing. This adjustment being made with minute care in the erecting shop, it is advisable for the operating engineer to leave it undisturbed, except in case of necessity. After the machine has been taken apart and put together again, a new adjustment must be made. This will be done with the machine slowly running. The thrust bearing is moved one way until a slight contact is noticed (the noise will be more easily detected by a proper piece of wood applied to the casing and the ear) then brought back the desired amount of clearance.

The dummy rings and balancing pistons can be dispensed with in double-flow turbines (Westinghouse) and in impulse turbines. For the latter type the leakage losses take place through the clearance left between the shaft and the diaphragms, which are fixed disks bearing the nozzles. A labyrinth groove packing is generally provided at this point and requires a narrow radial fit of similar accuracy to those above mentioned.

The steam consumption of a turbine depends largely upon the maintenance of the initial clearances; the greatest care must be taken to avoid their reduction or destruction, as by vibration.

Gland Packings

A few types of turbines, especially the original Parsons turbine, apply the principle of the labyrinth to the stuffing-boxes, too. This has the advantage that friction losses are absolutely avoided, at the cost, it is true, of a small steam loss.

The leading firms in this country have adopted devices of another kind; the General Electric Co. uses a carbon packing, the Westinghouse and Allis-Chalmers companies a water-gland packing. With the former the engineer will have to remember that the carbon rings should have a loose fit on the cold shaft; as carbon does not expand but contracts through heat, the expansion of the shaft would open the segments of an exactly fitting ring when warming up, and leakage would occur. The carbon rings do not need lubricating, but are likely to break and wear out. In the long run they have been seen to cut regular grooves in the shaft; the latter, therefore, often has an interchangeable bushing.

The water-gland packing insures a perfect closing of the turbine, but the runner, forming a little centrifugal pump which forces the water in a circumferential sealing space, absorbs a certain amount of power. Besides, if the water is not perfectly clean, it will deposit scale in the glands which has to be removed, sometimes frequently. Finally the water which passes into the turbine will evaporate there, and may cause the formation of a considerable layer of scale on the blades, with a very detrimental effect on the steam consumption. The water supply must be carefully regulated to keep the leaking quantity as small as possible. To avoid evaporation in the glands the temperature should be the lowest obtainable. The water should come to the glands with a few pounds pressure.

Bearings

The next important parts to be considered are the bearings. They constitute with a few gears (worm-gear for governor shaft, tachometer drive, oil-pump gear) the only parts of the turbine where actual metallic friction takes place. As no other acting forces are transmitted by the shaft besides its own weight, the wear of the babbitt shells will be extremely little. The bearings are flooded with oil under pressure; this enters between the babbitt and spindle and forms a continuous film, acting like an elastic cushion. The oil pressure is furnished either by a special oil pump driven from the turbine shaft, or by gravity. Both systems have their merits. The self-contained system is independent of outside help; the oil is stored in a compartment of the bedplate, is thence pumped through a cooling coil in an adjacent cooling chamber of the bedplate, and conveyed to the bearings by a piping system. Once the oil-regulating valves on the bearings are adjusted, they need not be touched again, the oil supply being an automatic function of the turbine shaft's revolution. A disadvantage of this system is the necessity for an auxiliary steam- or hand-driven oil pump, as the main pump does not deliver enough pressure right from the start.

Oil pumps of various designs have been used; plungers, gears, centrifugal or helicoidal, any of these constructions can be depended upon. For gear and helicoidal pumps the decrease of delivery due to the wear must be considered.

In a gravity system the oil is supplied to the bearings from an elevated tank to which it is returned after use by a separate oil pump. The circuit in this case is longer, and the stored quantity of oil can be much larger. This has been found by experience to be favorable, the deterioration of the oil being less rapid. It is claimed as another advantage that the oil-piping system is more accessible for inspection and repair.

With either system the oil consumption of the bearings should be correctly adjusted, so that the rise of temperature between inlet and outlet will be approximately the same for all bearings.

The Governor

A part of great importance in every turbine is the governing mechanism. The governor is of the centrifugal spring-weight type, and either attached directly to the turbine shaft or mounted on a special shaft, driven from the turbine shaft by cut gears (worm-gear). The gear works in an oil bath.

The governor has to move only a small pilot valve which regulates the admission of oil (under pressure) to the relay—or servomotor cylinder, the piston of which acts either directly on the steam valves, main and bypass, or determines the motion of the mechanical valve-gear, as in the General Electric turbine.

This method of oil-relay regulation is most sensitive; quite sudden load changes have only a slight reaction on the speed of the machine, and, with full load thrown off, the increase in the number of revolutions is ordinarily guaranteed not to exceed 2 or 3 per cent.

An important feature is that the oil supply to the bearings and to the governor are interconnected so that the relay-piston will automatically shut off the steam if the oil supply fails and endangers the bearings.

In case of any accidental derangement of the main governor mechanism, a separate safety-stop or overspeed governor, mounted directly on the shaft, comes into action and instantly shuts off the steam supply, whenever the speed exceeds a predetermined number of revolutions (say, for instance, 8 to 12 per cent. over the normal).

Attendance

Obviously, all precautionary measures have been taken to make the turbine the most reliable prime mover, and the easiest to handle. For simplicity of attendance, low cost of maintenance and repairs the turbine is far ahead of the reciprocating engine. There are, in particular, no use for the oil can, no filling of oil cups, no oil dripping and constant wiping, as on the engine. There are no reboring of cylinders, no setting of valves, no readjustment of worn out parts, loose pins and journals and so on. There is practically no packing, as, apart from the main stuffing-boxes, no glands whatever are used, valve stems, etc., being ground in their bushings.

Accidents

Stunts of various kinds and breakdowns have happened to turbines in the past and will happen in the future, but accidents with heavy loss of property and life, as they occur time and time again with reciprocating engines (flywheel explosions) happen very seldom with turbines. One could easily sum up the few cases of turbine explosions due to runaways, where wheels or rotors have burst on account of excessive velocity, and water-hammer is an unknown danger in steam turbines.

Nobody can, evidently, give an absolute guarantee that occasional material defects will not cause a blade to break and cause some mischief in the machine, but such an event, if it is not unavoidable, is at least no extreme misfortune. A row or two of the damaged blades are quickly taken out, and if they cannot be replaced at once, they may be left out and the machine run without them until repairs can be made.

Starting a Turbine

A turbine to be started for the first time, or after a long stop, should be cleaned and inspected with special care. This applies chiefly to the bearings, the oil pipes and oil reservoirs, where the least particle of dirt or grit is harmful. The steamways and piping should be gone over, too, very carefully. Instances where bolts, nuts, waste and other articles have been found on such inspection in the casing, the steam channels or valves, are not at all uncommon. The steam pipe should be blown out from the boilers, the last connection to the turbine being removed. All kinds of dirt, chips of gaskets, red lead, etc., will appear at this occasion, which would have obstructed the steam passages (guide vanes) if not removed.

The oil should be strained through cloths when poured into the machine. A sufficient quantity must be provided. The air should be driven out of the oil piping by operating the auxiliary oil pump. The bearings will have to be generously oiled before starting.

Revolving the shaft by hand will show if there is any hindrance to its free rotation. This preliminary work being done, the warming up of the turbine can begin. Like a steam engine a turbine needs a thorough warming up before being loaded. This prevents unequal expansion of rotating and fixed parts, which would follow a sudden exposure to steam. To begin with, open the throttle valve just a little and increase gradually; open the drains and leave them open until the turbine is nearly full speed.

The time required for warming up depends upon the type and size of turbine. Large turbines need more time than small ones. Reaction turbines require a more careful treatment on account of the smaller clearances and the large mass of the rotor. One-half to two hours is not too much for these machines. For impulse turbines half this time may be sufficient. In an emergency, when a turbine must take up the load of a broken-down unit as quickly as possible, the time for warming up may be considerably shortened. A practice followed in Germany, is to start the turbine running slowly from the beginning, the warming up going on while the speed is gradually increased.

During the time the turbine is warming up, the auxiliary machinery can be got under way. Where the turbine has water glands, the vacuum can only be created and the air pump started after the turbine is at a certain speed, because the glands do not act before a certain centrifugal force is developed and until then a great quantity of air can pass through the stuffing-boxes into the condenser. If a central condenser is used, such a turbine has to be put up to speed with the valve between the turbine and the condenser closed, exhausting in the meantime to the atmosphere.

A turbine should always be speeded up slowly. If accelerated too quickly, vibrating may start quite unexpectedly and continue a good while after starting. The passage of the critical speed, if a flexible shaft is used, is an exception to the above rule; it has to be done promptly, as in that range of revolution vibrations have a particular tendency to develop and to increase dangerously.

After normal speed is reached, with a good vacuum established, the load should be put on by steps, to avoid a sudden inrush of steam into the turbine, which will very likely be accompanied by a water slug.

If the turbine is to run in parallel with other units the governor can be adjusted for variable speed while the turbine is in operation, thereby facilitating the synchronizing of alternators.

It is helpful to always follow the same routine of duties when a turbine is started or stopped; for instance, the operation of the auxiliary oil pump has to be combined with the observation of the pressure gage which indicates the moment when the main pump begins to work; the moment for opening the water-supply valve to the cooling coil must be delayed until the oil is warmed up a little and becomes more fluid, etc.

Operation

Although the turbine takes care of itself automatically, so to speak, and intelligently, it must receive due attention.

At regular intervals, the engineer in charge of a watch should go over his machine, observe the pressure and vacuum gages, the tachometer, measure the

temperatures of the bearings and of the oil, and inspect the water supply to the cooling coil, the packing glands or the water-cooled bearings, if there are any.

An equal share of supervision should be given to the condensing plant, and especially should any drop of the vacuum or irregular behavior of the vacuum gage incite to a thorough investigation.

The sources of trouble in a turbine can often be located in the oiling system. It should be seen to that the cooling coil remains effective, that deposits of mud through the water, or of gum or vaseline-like substances on the side of the oil, be removed. The water used for cooling and other purposes should be clean; if necessary it should be filtered or treated against scale-forming elements.

The oil should be of the best quality; the cheaper grades are always more costly in the end, they deteriorate more rapidly and besides cause trouble. Only pure mineral oil of not too high viscosity —a light-bodied oil—is to be used. Acids in the oil are strictly prohibitive. Admixture of vegetable oil gives a tendency to gum; the hydrocarbons present in mineral oils, when mixed with vegetable oil separate out as precipitate and cause trouble by clogging.

The temperature of the oil at the outlet of the bearings should be about 140 deg. F.; not much higher, for fear of heating, nor much lower, for the sake of fluidity.

If a bearing gets hot it can be easily smelled and seen by the dense white fumes of the burning oil. There is generally some radical cause for a hot bearing, which should immediately be removed—a tight cap, grit or foreign substances in the oil, insufficient oiling. The maximum oil supply should be tried, and if this gives no relief the turbine should be stopped at once rather than have the bearing burn out. Then cleaning and inspecting should follow. It is to be remembered that quick action is necessary; the high circumferential speed of the journal does not allow much chance for reflection or hesitation, and there is no time for nursing the bearing back into good condition. Troubles with the bearings are, however, rare if the oil is carefully looked after, filtered frequently and the strainer cleaned.

Vibration

Any other, and especially internal diseases of a turbine, are indicated by one sure symptom—vibrating of the machine. The vibrations tell the sensitive expert a whole story about the complaints of his engine; they constitute, in power-house language, the particular mode of speaking of the turbine, less expressive perhaps than the pounding and knocking of a reciprocating engine, but always a certain sign that something is wrong.

The diagnosis of the evil is not always easy and the causes of vibration may be various. First, it is never possible to balance the parts of a rotating mass so as to make the center of gravity coincide exactly with the geometric center about which it revolves; hence vibration. At certain definite speeds, called critical speeds, this vibration becomes excessive, while below and above, the motion may be perfectly smooth, as long, at least, as the unbalanced masses are small.

A considerable lack of balance causes vibration at any speed, and is the principal, if not the only, cause of all vibration. It has been known to result from the irregular expansion of the rotor due to quick warming up, but every sudden change (especially rise) in temperature may equally provoke distortion of the wheels or a warping of the spindle. When superheated steam is dealt with this point should always be observed. A change from condensing operation to atmospheric exhaust calls for attention for this same reason, and should not be rushed.

On the other hand, water drawn into the turbine with the steam will act as a very effective unbalancing mass and mostly with very bad consequences; and very obviously a blade flying off will create an overweight on the opposite side of the rotor without regard to the other effects.

Vibration due to any one of these causes always has the same effect; it brings the revolving and stationary parts of the labyrinths into contact, with friction, heat and deformation as results, and the least that will happen will be the destruction of the small clearances, and increased leakage and steam consumption.

It is therefore always advisable, when a turbine begins to vibrate for some unknown reason, to moderate the speed at once and to give the rotor an opportunity to get into good shape again. If the vibration persists after a new start, and goes on increasing, the trouble is probably of a serious nature and should be looked after.

Sometimes it is difficult to locate exactly the source of vibration, as it may be due also to the driven machine. Or each one of the two machines may individually be well balanced, but if both shafts are not truly aligned they will never work properly together and permanent vibration will result, especially if a rigid coupling is used. For this reason preference is given to elastic couplings, which will accommodate themselves to a slight lack of alignment without affecting the behavior of the whole machine.

A few rules as to desirable general operating conditions might here be touched upon.

Superheated Steam

If at all possible, turbines should be supplied with superheated steam. Conclusive tests have shown its advantageous influence on the water-rate efficiency, but there are, besides, a few practical reasons which must be considered. In the first place the probability of getting water into the turbine becomes much smaller, and further, superheated steam causes far less erosion of the blades than wet steam. The cost of adding superheaters to an existing plant should not be regarded if this improvement is possible; the money spent will prove a good investment. Saturated steam should be controlled in its degree of moisture; forcing boilers increases this amount and is not good practice.

Vacuum

Another important point in the line of economy is maintaining a high vacuum. The ability of the turbine to make use of the expansion up to the last limit is sufficiently known, and thermally spoken, it is the last inch which gives the largest gain. Evidently the question is to be considered from the standpoint of the condensing plant, too, for at a certain limit the surplus work for the water-circulating pump overweighs the gain of the turbine.

In turbine plants large dimensioned condensers are usually provided. With either surface, barometric or jet condensers, a vacuum of 27 to 28 in. can easily be maintained and should be. The water temperature is here the principal factor, and other facts might have to be considered, which would require a detailed treatment. Running the condensing apparatus properly is a task which takes generally more of the engineer's time and attention than the turbine itself. Before leaving this subject the importance of frequently inspecting relief valves may be mentioned.

A last rule for the benefit of economy: reduce the amount of idle running of a turbine working in parallel with other units. Care should always be taken to handle the load so that no turbine runs for any length of time at much less than half load.

Shutting Down

When an independent turbo-generator is to be shut down, the throttle valve can be closed before the load is taken off; the latter acts as a brake and brings the turbine quickly to rest.

A turbo-generator running in parallel must have the load thrown off first and then the throttle quickly closed. Then the condenser is stopped and the steam drain opened to break the vacuum. Finally the water supply is shut off, but the oiling should be continued until the turbine is completely stopped.

Inspection

At regular intervals, and at least once a year, the turbine should be thoroughly inspected and all details gone over. This

applies to the interior of the turbine especially. Having lifted the cover, the clearances between rotary and fixed parts should be examined and readjusted. The rotor had better be removed and the blades minutely examined for erosion, scale, cracks, etc. The guide blades should undergo a thorough inspection, too, and be cleaned of obstructing matter.

The whole oiling system, chiefly, wants complete cleaning; the oil coils should be scraped outside and blown out with steam. Paraffin oil removes the gummy oxidized deposit, mentioned before as a result of bad oil. The oil strainer should be cleaned and an entirely new supply of oil put in. This is usually only necessary once a year; in the meantime the oil can be filtered and some new oil added to compensate for losses from leakage and evaporation. Bearings and stuffing-boxes will probably want some overhauling, too, and the governor and valves, the gears and oil pump should be gone over thoroughly. Great care must be taken in handling the rotor that no blades be injured; much trouble may arise from small damage.

The inspection will have to extend to the condensing plant. Air leaks may be looked for, and water leaks in surface condensers. Pumps, pipe lines, especially foot valves and strainers, must be cleaned and put in good shape.

Summing up the preceding statements, it doubtlessly will be conceded that the turbine requires less care and attendance than a reciprocating engine, and, if reasonably operated, maintenance and repairs amount to little. The engineer is thus relieved of much worry; he gets time now to devote his full attention to the problem of economical operation of his plant.

Let him think of plans to increase the general efficiency, of labor-saving devices and safety appliances, of precautions against shutdowns and of means for keeping track of performances. Recording thermometers and curve-drawing instruments should become his friends and help him watch conditions at any of the 24 hours of a day.

His duties are still more, for the modern engineer needs to know methods of testing fully, and, in the turbine plant, steam-consumption tests are the only means to control the efficiency of the machine. The indicator diagram, which affords an excellent guide to the reciprocating engineer, is of no use with a turbine. Steam measurements, compared with electrical output, are here the thing required.

The average engineer cannot be expected to proceed with the care used in acceptance tests, and refined measuring apparatus will generally not be at his disposal, but a scale for weighing the condensed steam and a few thermometers will give sufficient data for fairly approximate results.

In conclusion, let the engineer be careful of the external appearance of his turbine plant. He should pride himself upon things looking neat not only in the engine room, but also in the adjoining spheres of his activity, boiler rooms, basements, etc. In this endeavor modern design of power plants facilitates his task, as space, light, ventilation are more and more being provided.

Due to the reduced floor-space dimensions of a turbine, as compared with steam engines, the engine room will generally appear quite spacious, though in the basement things are still often crowded into inaccessible places. Let the engineer help progress also in this direction. And let him keep pace with the engine room; let him improve, with the introduction of turbines, not only his ability and knowledge, but also his personal appearance, social standing and dignity.

Shorter Cutoff, Greater Load

By F. R. Low

One of our subscribers has been having an argument with some fellow-engineers about the effect of changing the cutoff on the low-pressure cylinder of a compound engine. He writes:

"For the benefit of several engineers in this city, and possibly other places, I would be pleased to have you explain the apparent "paradox" whereby shortening the cutoff on the low-pressure cylinder of a compound engine will cause it to take more of the load.

"Some declare that the load can not be shifted from one cylinder to the other by manipulating the cutoff on the low-pressure, except to a very small extent. They declare that if they commence to shorten the cutoff on the low, and keep doing so, the engine will stop when that cylinder has taken a very small amount of the load, beyond what it had to begin with, assuming the load was equally divided at the start.

"I tried to tell them that it is possible to put nearly all the load on the low-pressure cylinder by shortening the cutoff. Also if the steam valves could be adjusted on the high-pressure side so as to take steam full stroke, that boiler pressure could be secured in the receiver by shortening the cutoff on the low, thereby causing it to take all the load, and a diagram from the high-pressure side would become a straight line.

"There is no difference of opinion as to the economy; the question is, can we change the load between the cylinders by changing the cutoff on the low-pressure, and to what extent? Please make this plain for there are many to whom this question is a puzzle."

The later the cutoff on the low-pressure cylinder of a compound engine the less work it does. The article explains this apparent paradox in such a way as to be easily understood.

The lower portions of Figs. 1 and 2 are the conventional diagrams of the high- and low-pressure cylinders respectively of a compound engine with the following data:

Initial pressure, 120 lb. absolute.

Cutoff in high-pressure, ¼ stroke.

Cutoff in low-pressure, ⅓ stroke.

Displacement of low-pressure piston, three times that of high.

Scale of high-pressure diagram, 60.

Scale of low-pressure diagram, 20.

These diagrams, to be comparable, must be reduced to the same scale, both of pressures and volumes. The high-pressure diagram would have been 60 ÷ 20 = three times as high as it is, if it had been plotted with the same scale of pressure (20) as the low, instead of on the 60-lb. scale to which it was plotted. The first step is to replot it upon the larger pressure scale.

Using the atmospheric line as a base, make $AB' = 3$ times AB; $CD' = 3$ times CD; $EF' = 3$ times EF, etc. The diagram would then become $B'D'F'G'HJB'$.

The horizontal dimension of such a diagram represents volume. The low-pressure piston displaces three times as much volume per stroke as the high, so that, if the length of the low-pressure diagram is taken as representing the displacement of that piston, the length of the diagram from the high-pressure cylinder must be made one-third the length of that of the low, for its length to correctly represent, to the same scale, the volume of the steam when it has expanded to fill the high-pressure cylinder.

Set off $ab = ⅓$ the length of the low-pressure diagram. Now squeeze the diagram up horizontally to this length. This is conveniently done by putting ordinates as 1′ 2′, 3′, 4′, into the reduced length spaced relatively to ordinates, as 1, 2, 3, 4, on the large diagram and transferring the pressures from one set of ordinates to the other. The pressure on ordinate 1 of the long diagram is 120 lb., as shown at D'. Make it the same on ordinate 1′ of the short diagram as at d. The pressure on ordinate 2 of the long diagram is 60 lb., as shown at F'. Transfer the same pressure to ordinate 2′ of

the short diagram as at *f*. Similarly the pressure, 40 lb. at *G'* on ordinate 3 of the large diagram is transferred to *g* on ordinate 3' of the reconstructed diagram. All that is necessary is to carry the pressures across horizontally. As many ordinates may be used as one chooses, but they must have the same relative positions in the two diagrams.

The high-pressure diagram, replotted to the same scales of pressure and volume as that of the low-pressure cylinder becomes *B'dfghJB'*. Placing this upon the low-pressure diagram so that the atmospheric lines coincide, we have the combined diagram shown in Fig. 2. Steam entering the high-pressure cylinder at 120 lb. absolute is cutoff at ¼ stroke, as shown at *B*, expanded to four times its volume at cutoff and hence to 120 ÷ 4 = 30 lb. at the end of the stroke in the high-pressure cylinder, as shown at *D*. The low pressure has three times the volume of the high, so that if it cuts off at ⅓ stroke it will take out of the receiver at each stroke the same volume that the high pressure delivers to it. There will therefore be no change of pressure in the receiver. The low-pressure cylinder takes out at each stroke a volume *CD*, Fig. 2, at 30-lb. pressure, and expands it to three times that volume (its cutoff being at ⅓) or to a pressure of 10 lb., as shown at *F*.

Whatever happens to the steam on its way through the engine it starts with a volume *AB* at the point of cutoff in the high-pressure cylinder and winds up with the volume *EF*, that is, the whole volume of the low-pressure cylinder, and, as it expands, the relations of its pressures and volumes will be expressed by some such line as *BDF*.

The work done in each cylinder is proportional to the area of its diagram. The work done in the high-pressure cylinder is proportional to the area *ABDCA* and that in the low to *CDFHGC*.

Now suppose the cutoff in the low-pressure cylinder to take place at ½ instead of ⅓ stroke. The volume of the high pressure is only ⅓ that of the low. If the low-pressure cylinder takes ½ of its own volume out of the receiver per stroke when only ⅓ of that volume is delivered to it the pressure in the receiver must drop and the steam in it expands until the greater volume taken out by the low pressure per stroke contains only the same weight as the lesser volume delivered to it by the high.

This means that the receiver pressure will be lower. Since the high pressure exhausts into the receiver its back pressure will be lower. The back-pressure line *CD*, of the high-pressure diagram would drop to *C'D'* and the area *CDD'C'C* would be added to the high-pressure diagram and taken out of the low, which would become *C'JFHGC'*. Since the work is proportional to the areas, the high-pressure cylinder is doing more work and the low-pressure cylinder less on account of the later cutoff on the low.

The high pressure does more on account of its reduced back pressure. The low pressure does less on account of its reduced initial pressure. A little area, *DJD'*, is not included in either diagram. This represents the work lost by free expansion in the receiver. It may have to be taken care of by a little later cutoff in the high-pressure cylinder, but this does not materially affect the argument.

If the cutoff in the low-pressure cylinder were carried back to ¼ stroke, as at *K*, the expansion would not follow the dotted line from that point, making that cylinder do less work, but the receiver pressure would rise to *LM*. The high-pressure cylinder diagram would become *ABMDNMLA*, having the loop *MND*, because it would expand the steam to *D* which would be lower than the receiver pressure. The further back the cutoff is carried the greater the loop becomes,

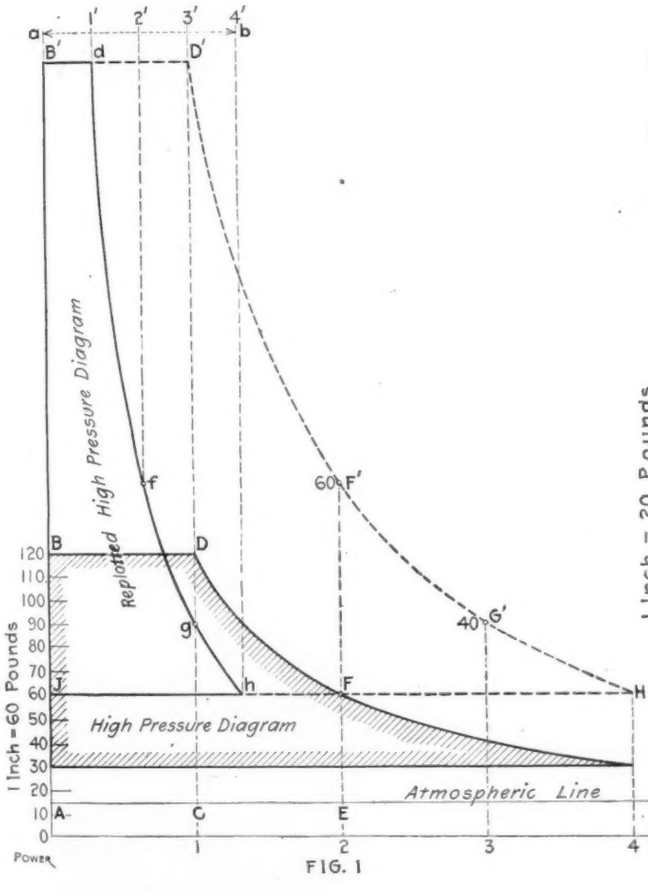

FIG. 1

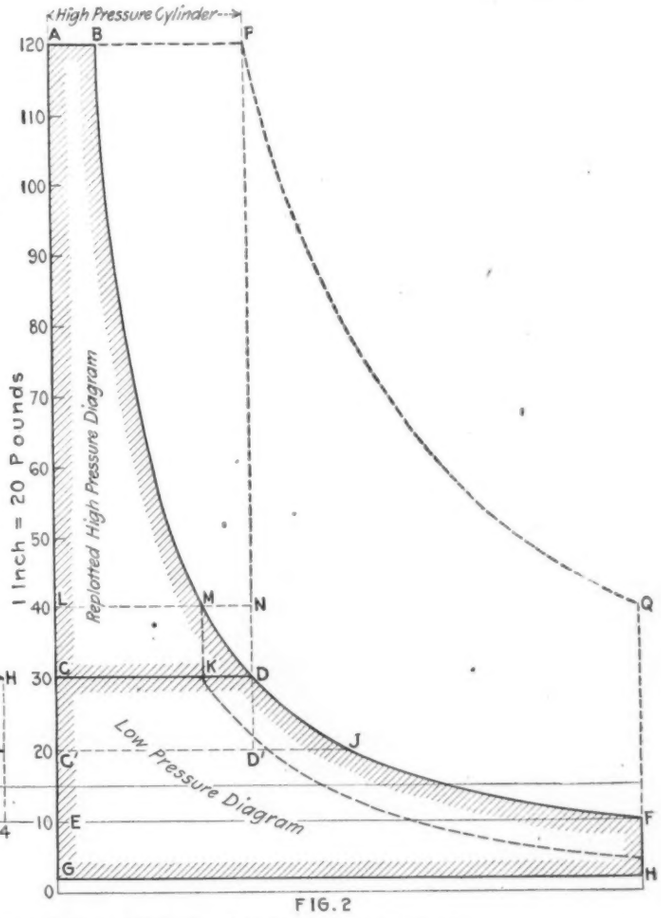

FIG. 2

THE SHORTER THE CUTOFF IN THE LOW-PRESSURE CYLINDER THE MORE LOAD IT CARRIES

until if it were carried back to $\frac{1}{12}$ stroke so that the volume taken out of the receiver were equal only to the volume *AB* coming to the high-pressure cylinder from the boiler, the receiver pressure would be equal to the boiler pressure and the high-pressure cylinder diagram would be a short straight line with an enormous negative loop represented conventionally by *ABDPBA*.

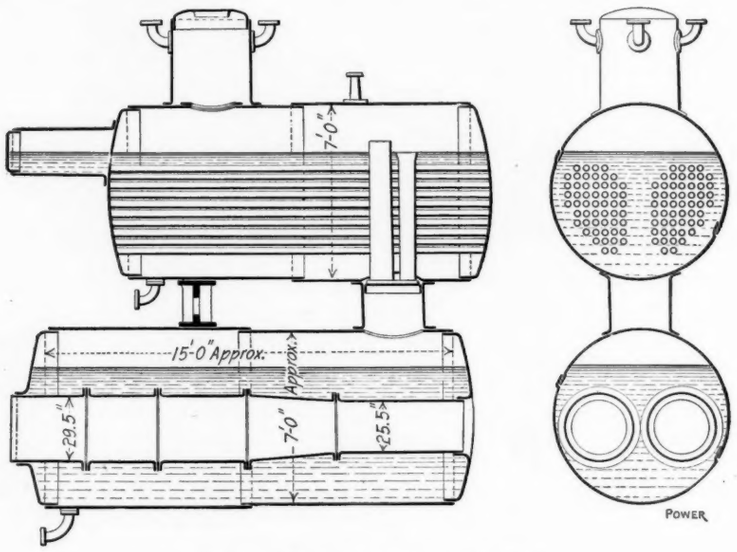

FIG. 1. SECTION THROUGH BOILER

This loop represents work done by the high-pressure piston in pumping back into the receiver the steam which flowed from the receiver into the high-pressure cylinder when its exhaust valve opened. It is therefore negative work, work imposed upon the engine in addition to its regular load. When the area of the loop becomes equal to the other, or positive part of the high-pressure diagram, the high-pressure cylinder is contributing nothing to the load, and the work available for running the engine will be only that represented by the low-pressure diagram. The useful work is the sum of the positive portions of both diagrams less the loop of the high-pressure diagram. For a constant load therefore the cutoff in the high-pressure cylinder would have to advance as soon as the diagram from that cylinder began to loop.

If, as our correspondent suggests, the steam were carried full stroke in the high-pressure cylinder with the low-pressure cutoff set so that the volume up to cutoff in the low just equalled the volume of the high, the conventional high-pressure diagram would become a straight line *AP*, Fig. 2, and the low-pressure diagram would represent the total work done by the engine.

The Legislature of Louisiana has passed, and the governor has signed an act making an eight-hour day for stationary engineers in that state.

Boiler Flue Deformed by Low Water

Inspector W. Ernst, in a communication to *Zeitschrift der Dampfkesseluntersuchungs und Versicherungs-Gesellschaft*, of Vienna, describes a serious case of low water where rupture of the boiler was prevented only by the prompt action of the operating engineer.

The boiler was of the Tischbein design, as shown in Fig. 1, and was built in 1899 with about 1600 sq.ft. of heating surface and for a working pressure of 156 lb. gage. The upper and lower elements of the boiler had two water columns complete with all fixtures, including two gage-glasses for each column and a feed connection. Normally and at the time of the accident only the upper element was being fed as the water was supposed to flow to the lower element through the shorter of the two interior pipes. This extended vertically from the dome of the lower element to the designed water level of the upper one, and was about 16 in. in diameter.

Two boilers of this kind were in service at the time, both fed and fired by one man. The recording-gage chart showed a pressure between 142 and 156 lb., indicating uniform firing. Not so, however, with the feeding, as at 4:30 o'clock that morning the operating engineer noticed that the water was not visible in either glass of the lower element of one of the boilers in service. A quick glance into the flues showed him the danger of the situation and notwithstanding the great distortion of the flues he showed his coolness by drawing the fires with the assistance of the boiler attendant and thus probably at almost the last moment prevented the rupture of the flues, the condition of which is shown in Fig. 2.

The pressure then dropped to about 100 lb., through the demand of a turbine up to that time in operation. The stop valve was then closed and the pressure again rose to 156 lb. as a result of the further evaporation due to the hot brickwork. At six o'clock the blowoff was opened and the boiler blown down.

An internal inspection of the boiler showed on the shell the gradual fall of the water level, but particularly was this noticeable on the conical course of each flue so that undoubtedly low water was the cause of the injury. The first three courses of each flue were bagged in, the deepest depression being about 10 in.

In this plant the feed water is chemically purified and but little sediment is deposited. The good condition of the boiler inside and of the water column and its fixtures and the tight blowoff valve showed conclusively that only the fireman's carelessness was responsible for the sinking of the water level to a point where the crowns of the flues were uncovered.

FIG. 2. SHOWING PARTIAL COLLAPSE OF FLUE

The operating engineer was rewarded by his employer for his opportune action and bravery in preventing a disaster.

Each person in the United States used 11,000 lb. of coal in 1910, said a speaker before the Missouri School of Mines recently.

Boilers with and without Conveyors

By Henry J. Edsall

Some calculations showing the saving effected under certain conditions by the installation of an overhead bin and conveyor system. The figures cited are taken from the operating records of an actual plant.

While it is a well recognized fact among engineers that one of the greatest savings obtained by the use of mechanical stokers is the economy in the labor cost, it is seldom possible to get a direct comparison of two boiler houses with the same boiler and stoker equipment, and the coal handled mechanically in one case and by hand in the other. The writer recently saw two such boiler houses, however, in the same plant of a large corporation and, as the conditions effecting the cost of making steam are about the same in the two boiler houses, a comparison will be interesting.

Boiler House A

A cross-section of boiler house A is shown in Fig. 1. The boilers are set in two rows, with a low trestle between, on which the coal cars are run in and unloaded, so that the coal is placed directly within reach of the firemen; no wheeling or second handling is necessary before shoveling it into the stoker hoppers, unless the coal pile under the trestle gets low. This arrangement, therefore, is better than many which are still to be seen in good-sized boiler houses. In addition to shoveling the coal, there is the additional labor of breaking up the large lumps and, as this is not always properly done, there is more or less grate-bar trouble with the stokers, thus reducing the efficiency of the steam plant as well as the additional cost of maintenance on the stokers.

Ash Handling

For ash-handling there is a bucket carried by an electrically operated telpher running on an overhead track. The ashes are raked from under the stokers up to the boiler-room floor and then shoveled into the bucket, which takes them out and delivers them into a railroad car. This means considerable labor and, as there is but little room between the boilers and the coal pile, the men get into each other's way.

Boilers

There are sixteen 260-hp. Babcock & Wilcox boilers in this boiler house, and all are equipped with Roney stokers. This makes a total rated capacity of 4160 hp. At the time the figures were obtained only 10 boilers were in use, the other six being cleaned and repaired.

The weekly coal consumption with 10 boilers in service averages about 910 tons, or 91 tons per boiler. Assuming roughly 10 per cent. ash, there would be about 91 tons of ashes to be disposed of each week. Table 1 gives the total weekly cost for labor, power and supplies directly connected with coal and ash handling.

In Table 2 the figures for boiler house A are changed to what they would be with 12 boilers in service, thus affording a direct comparison with boiler house B, where there are, as a rule, 12 boilers in use. The only changes are providing a fireman for each additional boiler, both day and night, and a slight increase in the power cost.

Boiler House B

In boiler house B there are fourteen 260-hp. Babcock & Wilcox boilers, or a total of 3640 hp. Usually 12 of these boilers are in use at one time, the other two being held for cleaning and repairs. In this boiler room the coal is fed from an overhead bin to the Roney stokers and a conveyor system handles both the coal and the ashes. The run-of-mine soft coal is unloaded into a track hopper underneath the track, then delivered to the crusher by means of an apron feeder, and after passing through the crusher a bucket carrier elevates it and distributes it in the overhead bin. The ashes are raked out of the hoppers and into the lower run of the carrier, which elevates them to an ash pocket from which they are discharged into railroad cars. Fig. 2 shows a cross-section of the boiler room thus equipped.

Fig. 1. Boiler House without Conveyor System, Ashes Removed by Means of a Telpher

TABLE 1. BOILER HOUSE A

Coal Trestle and Ash Telpher Equipment

Sixteen 260-hp. boilers, ten in service; weekly coal consumption, 910 long tons

No. of Men	Duties of Men	Hours per Week, Each	Hourly Rate	Weekly Rate, Each	Total per Week
1	Telpher operator (day)	79	$0.18	$14.22	$14.22
1	Telpher operator (night)	89	0.18	16.02	16.02
3	Loading ashes to telpher (day)	79	0.18	14.22	42.66
3	Loading ashes to telpher (night)	89	0.18	16.02	48.06
3	Unloading coal from cars (day)	72	0.15	10.80	32.40
2	Unloading coal from cars (night)	78	0.14	10.92	21.84
1	Chief (day)	79	0.25	19.75	19.75
1	Chief (night)	89	0.25	22.25	22.25
1	Assistant chief (day)	79	0.22½	17.78	17.78
1	Assistant chief (night)	89	0.22½	20.03	20.03
10	Fireman (day)	79	0.18	14.22	142.20
10	Fireman (night)	89	0.18	16.02	160.20
		..	....	.....	$557.41
	150 hp.-hr. for telpher motor at 3 cents	..	....	.....	4.50
	Supplies for telpher	..	....	.....	*2.00
	Total per week	..	....	.....	$563.91

Coal Consumption

The average amount of coal consumed per week with 12 boilers in service is about 1260 tons, or 105 tons per boiler. This is an increase of about 15 per cent. over the amount of coal consumed by the boilers in boiler house A, which means that a greater output of steam is obtained from these boilers, because the coal is properly crushed and is fed continuously to the stokers, resulting in better and more even fires. Figuring 10 per cent. ash, as before, about 126 tons of ashes are disposed of.

Hours and Wages

The hours and wages of the men are given in Table 2, which shows a total

weekly labor cost of $395.09. The power used for handling coal is figured on the basis of 30 tons per hour, which is about the average amount handled. This gives a total of 42 hours per week, and taking the average horsepower consumed as 20, gives a total of 840 hp.-hours per week for handling coal. The actual amount of power used in handling ashes is hard to determine, but 660 hp.-hours per week would cover it, making a total of 1500 hp.-hours per week for handling both coal and ashes.

This gives a total weekly cost of $445 for boiler house B against a cost of $625 for boiler house A, or a saving of $180 per week and $9360 per year. This, of course, does not include the cost of maintenance and the depreciation of the coal- and ash-handling equipment or the interest on the investment in either case.

Overhead Bin and Conveyor System

Since the foregoing figures were obtained, four more boilers have been installed in boiler house A and, as the possible saving increases with a greater number of boilers, the advantages of an overhead bin and conveyor system for handling both coal and ashes are still more strikingly shown when the costs for this boiler house, with twenty boilers, are worked out.

Such a comparison is shown in Table 3, the first part showing the costs with the present type of equipment and the second part showing the costs with the overhead bin and conveyor system, the number of boilers in service being assumed as 16, and the wages, etc., being based on the actual figures obtained for the two boiler houses. No men are added for the present type of equipment except the firemen, though with this number of boilers in service there might be more men required for loading ashes to the telphers or for unloading coal from the cars.

With the overhead bin and conveyor system two day men and two night men are included for handling ashes. Having an efficient modern system this number should be ample; in fact, one man should be able to handle the 10 or 12 tons of ashes on each shift—about one ton per hour.

The excavating and concrete work for the ash hoppers and tunnels, etc., would make the installation of this system in an old boiler house considerably more expensive than in a boiler house designed especially to suit these conditions. The total cost of installation has, therefore, been assumed as $50,000, including an overhead coal bin with a capacity of 900 tons.

TABLE 2

Boiler House A

Coal Trestle and Ash Telpher Equipment

Sixteen 260-hp. boilers, twelve in service; weekly coal consumption, 1092 long tons

No. of Men	Duties of Men	Hours per Week, Each	Hourly Rate	Weekly Rate, Each	Total per Week
1	Telpher operator (day)	79	0.18	$14.22	14.22
1	Telpher operator (night)	89	0.18	16.02	16.02
3	Loading ashes to telpher (day)	79	0.18	14.22	42.66
3	Loading ashes to telpher (night)	89	0.18	16.02	48.06
3	Unloading coal from cars (day)	72	0.15	10.80	32.40
2	Unloading coal from cars (night)	78	0.14	10.92	21.84
1	Chief (day)	79	0.25	19.75	19.75
1	Chief (night)	89	0.25	22.25	22.25
1	Assistant chief (day)	79	0.22½	17.78	17.78
1	Assistant chief (night)	89	0.22½	20.03	20.03
12	Firemen (day)	79	0.18	14.22	170.64
12	Fireman (night)	89	0.18	16.02	192.24
					$617.89
	Weekly cost of power for telpher	..	.....	.....	5.11
	Weekly cost of supplies for telpher	..	.....	.....	2.00
	Total per week	..	.....	.....	$625.00

Boiler House B

Overhead Bin and Conveyor Equipment

Sixteen 260-hp. boilers, twelve in service; weekly coal consumption, 1260 long tons

No. of Men	Duties of Men	Hours per Week, Each	Hourly Rate	Weekly Rate, Each	Total per Week
1	Conveyor operator (day)	76	$0.30	$22.80	$22.80
1	Conveyor operator (night)	85	0.30	25.50	25.50
2	Feeding ashes to conveyor (day)	76	0.16½	12.54	25.08
2	Feeding ashes to conveyor (night)	85	0.16½	14.03	28.06
3	Unloading coal from cars (day)	72	0.15	10.80	32.40
1	Chief (day)	79	0.25	19.75	19.75
1	Chief (night)	89	0.25	22.25	22.25
1	Assistant chief (day)	79	0.22½	17.78	17.78
1	Assistant chief (night)	89	0.22½	20.03	20.03
6	Firemen (day)	79	0.18	14.22	85.32
6	Firemen (night)	89	0.18	16.02	96.12
					$395.09
	Weekly cost of power for conveyor system (1500 hp.-hours @ 3 cents per hour)	..	.....	.....	45.00
	Weekly cost of conveyor-system supplies	..	.....	.....	4.91
	Total per week	..	.....	.....	$445.00

TABLE 3

Boiler House A

With Present Coal Trestle and Ash Telpher Equipment

Twenty 260-hp. boilers, sixteen in service; weekly coal consumption, 1466 long tons

No. of Men	Duties of Men	Hours per Week, Each	Hourly Rate	Weekly Rate, Each	Total per Week
1	Telpher operator (day)	79	$0.18	$14.22	$14.22
1	Telpher operator (night)	89	0.18	16.02	16.02
3	Loading ashes to telpher (day)	79	0.18	14.22	42.66
3	Loading ashes to telpher (night)	89	0.18	16.02	48.06
3	Unloading coal from cars (day)	72	0.15	10.80	32.40
2	Unloading coal from cars (night)	78	0.14	10.92	21.84
1	Chief (day)	79	0.25	19.75	19.75
1	Chief (night)	89	0.25	22.25	22.25
1	Assistant chief (day)	79	0.22½	17.78	17.78
1	Assistant chief (night)	89	0.22½	20.03	20.03
16	Firemen (day)	79	0.18	14.22	227.52
16	Firemen (night)	89	0.18	16.02	256.32
					$735.85
	Weekly cost of power for telpher	..	.....	.....	8.15
	Weekly cost of supplies for telpher	..	.....	.....	3.00
	Total per week	..	.....	.....	$750.00

Boiler House A

Equipped with Overhead Bin and Conveyor System for Handling Coal and Ashes

Twenty 260-hp. boilers, sixteen in service; weekly coal consumption, 1680 long tons

No. of Men	Duties of Men	Hours per Week, Each	Hourly Rate	Weekly Rate, Each	Total per Week
1	Conveyor operator (day)	76	$0.30	$22.80	$22.80
1	Conveyor operator (night)	85	0.30	25.50	25.50
2	Disposing of ashes (day)	76	0.16½	12.54	25.08
2	Disposing of ashes (night)	85	0.16½	14.03	28.06
3	Unloading coal from cars (day)	72	0.15	10.80	32.40
1	Chief (day)	79	0.25	19.75	19.75
1	Chief (night)	89	0.25	22.25	22.25
1	Assistant chief (day)	79	0.22½	17.78	17.78
1	Assistant chief (night)	89	0.22½	20.03	20.03
8	Firemen (day)	79	0.18	14.22	113.76
8	Firemen (night)	89	0.18	16.02	128.16
					$455.57
	Weekly cost of power for modern conveyor system	..	.....	.....	40.00
	Weekly cost of supplies for modern conveyor system	..	.....	.....	4.43
	Total per week	..	.....	.....	$500.00

Cost of Maintenance

Assuming then that a loan of $50,000 is obtained at 5 per cent. interest, and that 3 per cent. per year will cover the cost of maintenance, the following saving is effected:

Weekly saving, $750 — $500 = $250; yearly saving, $250 × 52 = $13,000.

TABLE 4

	Maintenance	Interest	Net Saving	Unpaid Balance of Loan
First year.	$1500	$2,500.00	$9,000.00	$41,000.00
Second year...	1500	2050.00	9,450.00	31,550.00
Third year...	1500	1577.50	9,922.50	21,627.50
Fourth year...	1500	1081.38	10,418.62	11,208.88
Fifth year	1500	560.44	10,939.56	269.32

That is, the installation would pay for itself in a little over five years, and each year after this shows a clear saving of several thousand dollars. The 3 per cent. for maintenance should be ample, as much of the installation cost is for foundation work, concrete and steel bins, etc., which work would be either permanent or require but little for maintenance. Besides, coal and ash conveyors have reached a point of perfection in design and construction where they will stand up wonderfully well under very severe service, and the handling of both coal and ashes in one carrier is now good engineering practice.

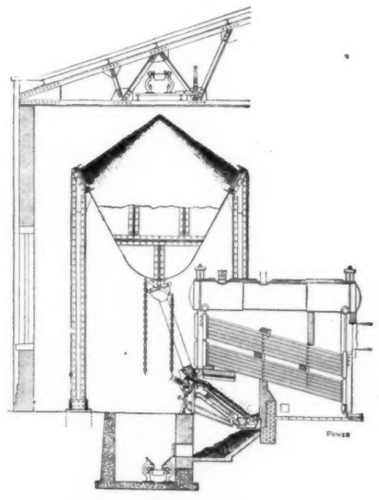

Fig. 2. Section through Boiler House Showing Conveyor System

In fact, a well designed carrier embodying first-class construction throughout should, when handling both coal and ashes, require little or no repairs in the first four or five years, and after this 3 per cent. per year would probably cover them, unless the amount handled is unusually large, in which case the cost per ton of material would show to even better advantage.

Notes on Friction and Lubrication

By Richard Howarth

The friction between two surfaces is greater when at rest than when in relative motion, but when in motion it is practically independent of the velocity so long as the surfaces are kept cool. The friction between two surfaces, dry or only slightly lubricated, is in direct proportion to the force with which they are pressed together within the limits of abrasion, and it is independent of the area of the surfaces in contact. With ample lubrication, the friction is naturally reduced, but the heavier the pressure per unit of surface, the greater must be the consistency of the oil to prevent it from being squeezed out of the bearing.

The friction under motion when the surfaces are dry is on the average 20 to 40 per cent. less than the friction of rest, and with ample lubrication the reduction averages 80 per cent. for low pressures to 98 per cent. for high pressures. If one could take a pair of absolutely true surface plates and place them together they could be moved over each other with a minimum force, as if the thin film of air formed a roller bearing; but if pressure is applied and the air is squeezed out, the surfaces are liable to seize and can be moved over one another only with difficulty.

The ordinary theory of solid friction is that it varies in direct proportion to the load; that it is independent of the extent of the surface in contact, and that it tends to diminish with an increase of velocity beyond a certain limit. The theory of fluid friction, on the other hand, is that it is independent of the pressure per unit of surface, and is directly dependent on the extent of surface and increases as the square of the velocity. The results of various experiments tend to show that the friction of a perfectly lubricated journal follows the laws of fluid friction more closely than those of solid friction; they show that under these circumstances the friction is nearly independent of the pressure per square inch, and that it increases with the velocity, though at a rate not nearly so rapid as the square of the velocity.

The coefficient of friction μ is the ratio of the pressure P required to overcome the friction of a body on any given horizontal surface to the whole load W or

$$\mu = \frac{P}{W}$$

Trigonometrically, it is equal to the tangent of the limiting angle of resistance,

$$\mu = tan.\ \phi$$

Friction of any kind, however produced, results in the conversion of mechanical work into heat. One horsepower, or 33,000 ft.-lb. of work per minute, expended in friction produces

$$\frac{33,000}{778} = 42.4\ B.t.u.\ per\ minute$$

Bearings

Increasing the diameter of a shaft increases the friction because the rubbing surfaces have farther to travel in one revolution; whereas, increasing the length reduces the friction per square inch, but does not affect the total friction, because for a given space passed through with a constant load the friction is independent of the surfaces in contact.

The bearing area is taken as the length multiplied by the diameter. When an overhanging bearing is increased in length the diameter must also be increased slightly to give the same strength as before.

Pressure on the journals in pounds per square inch longitudinal section may be

$$P = \frac{70,000}{50 + V}$$

in which V = velocity in feet per minute. Of course, P must never exceed 1000 as a maximum, or preferably about 800 lb. in slow-running engines down to 400 lb. in very high speed engines.

Lubricants

The lubricants commonly used for various classes of machinery, with very great pressure and slow speed, are graphite, tallow, vegetable grease and soapstone; with heavy pressure and high speeds, sperm oil, refined petroleum, olive and rape oil are employed. For steam-engine cylinders heavy mineral oil is best. If animal and vegetable fats were used in engine cylinders they would be decomposed by the high temperatures into acids having a corroding effect on the cast iron.

Cylinder oils, in common with other lubricants, should be absolutely neutral in their natural condition and incapable of developing acid when in use. They should also be free from mucilaginous or gumming properties and from dirt or grit. A good cylinder oil should have a specific gravity of about 0.9 at a temperature of 60 deg. F., and a flash point not less than 500 deg. F.

Cylinder oils may be rapidly tested for gumming properties by exposing them for 6 hr. in thin films to the action of steady currents of hot air at a temperature of about 300 deg. F. Oils have a tendency to oxidation and different oils display to a widely divergent extent their affinity for oxygen. In the best grades of mineral oils this tendency is entirely absent. Some of the lower grades of mineral oils have a tendency to discolor bright metallic surfaces and to produce thin, varnish-like films, which are doubtless due to the presence of the products of oxidation.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Inspecting and Testing Electrical Apparatus—I

By A. L. Cook

In large systems it is often necessary to make extensive tests before the apparatus is put in service and in such cases an expert is usually called in. Where no very complicated switching is involved or the system is small and the expense of a specialist not justified, the electrician or operator would be expected to make tests.

In this series of articles will be taken up the methods of inspecting and testing ordinary alternating- and direct-current generating and transforming apparatus.

Direct-current Systems

The direct-current systems most common are those supplying power and light to relatively small areas, or for a single building using 125 or 250 volts on a simple two- or three-wire system; and those for railway or power service, using 500 or 650 volts on a two-wire system.

It is essential, before making tests on new apparatus, to make sure that the switchboard equipment is in proper condition. All main connections should be carefully checked to see that the terminals of each generator connect through the switches and fuses and circuit breakers to the proper busbar. Two-wire compound-wound generators usually have the series field connected to the positive terminal. However, in grounded systems, such as for railway service, the series winding is often on the negative or grounded side. Anywhere that generators are to be run in parallel, all the series windings should be on the same side so that they can be placed in parallel through the equalizer busbar.

If circuit breakers of the ordinary laminated brush, carbon-break type are used the contact surfaces should first be wiped off as a little dirt may cause heating sufficient to oxidize the copper contacts, which will further increase the heating, and finally take the temper out of the brush. An imperfect contact can be detected by closing the breaker with a piece of tissue paper between the brush and the blocks. When the breaker is open, the mark left on the paper will indicate whether it is properly adjusted. The carbon blocks should make firm contact until the main brush has left the upper block, so that the final break in the circuit will take place on the carbon blocks, and save the main copper contacts from pitting. The breaker should be tripped several times by hand, and finally set to trip at the desired overload. For a new machine it is well to set this low, say 25 per cent. overload, until the generator has been well tried out, after which it can be set at 50 per cent. overload or more, if the generator will stand it.

Knife switches should be examined for clean surfaces and good contact between the clips and the switch blade. Vaseline or oil can be rubbed on the contact surfaces to keep them from cutting; a very little is sufficient. The back of the switchboard should be inspected to make certain that all contacts are tightly bolted and that there are no short-circuits. Fuses should be examined and the wiring tested for grounds and to make sure that the insulation resistance is not below a safe minimum.

Testing Insulation

Several methods for testing insulation are suitable for direct-current systems. A ground or short-circuit can be detected by a battery and buzzer or by an incandescent lamp, placing the apparatus in series with the testing circuit. These methods will indicate, however, only a complete ground or a leak in the insulation of a very low resistance, and if possible, some other method should be used.

A very common method, which is also employed extensively during the erection of electrical apparatus, is the use of a magneto-generator and bell, similar to that used for telephone lines. Both the generator and bell are generally mounted in one box having two terminals for the testing leads. One lead is connected to ground and the other to the apparatus to be tested. When the magneto-generator is turned rapidly, the bell rings if a ground exists on the apparatus. These magneto sets are rated according to the resistance through which they will ring; that is, a 100,000-ohm magneto will ring when the resistance between the ground and the apparatus is 100,000 ohms or less. The loudness of the ringing is an indication of the insulation resistance tested; if the bell does not ring, the resistance is more than 100,000 ohms. The same applies to magneto-generator sets rated lower. A magneto-generator cannot be used satisfactorily to test an underground cable 1000 ft. or more long, as the electro-static capacity of the cable causes the bell to ring even if no ground exists.

Sometimes it is necessary to test insulation resistances higher than can be indicated by a magneto. Then, if a supply of direct current is available, a voltmeter may be used to advantage with the connections as shown in Fig. 1. The supply voltage is first read by connecting the leads *A* and *B*, as indicated by the dotted line. Then this connection is broken and lead *B* is connected to the ground and lead *A* to the conductor to be tested and the voltmeter is again read. The resistance between the conductor and the ground may be expressed by the formula:

$$R = r\left(\frac{V - v}{v}\right)$$

where

R = Resistance to be measured;
r = Resistance of the voltmeter (generally marked on the inside of the instrument case);

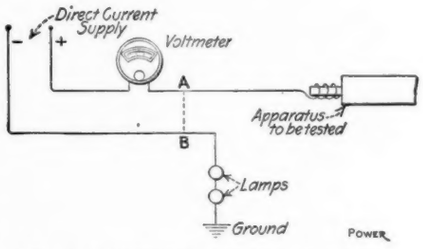

Fig. 1. Showing Method of Testing for Ground

V = Supply voltage as first measured;
v = Reading of the voltmeter when connected to the apparatus.

For example assume the voltmeter resistance is 15,000 ohms, the voltage V is 125, and v is 2 volts; then

$$R = 15{,}000\left(\frac{125 - 2}{2}\right) = 922{,}500 \text{ ohms}$$

If the supply is taken from the busbars and it is not desirable to ground one of them directly, the ground can be made through a low resistance, such as one or more incandescent lamps in series, the number depending upon the voltage of the system. If the test is made with a railway circuit which is grounded, the voltmeter should be connected to the permanently grounded busbar. In any case the voltmeter should be placed in series with the lead connected to the apparatus and not that connected to ground. One must be careful not to touch the bare terminal of lead *A*, or the conductor of

the apparatus being tested, as the leakage through the body would be sufficient to greatly change the reading v of the voltmeter. Sometimes when lead A is first touched to the apparatus to be tested, there is a momentary kick of the pointer. This is not an indication of the insulation resistance and the reading v should be taken only after the voltage has been applied for a few seconds and the voltmeter pointer has come to rest.

The resistance which can be measured by this method depends upon the supply voltage and the resistance of the voltmeter. Special voltmeters are made having a resistance of about 1,500,000 ohms with a 600-volt scale which, on a 500-volt testing circuit with a reading v of 5 volts, would indicate a resistance of 148,500,000 ohms or 148.5 megohms. These instruments are somewhat delicate to handle, however, and are more sensitive than is needed for ordinary tests. The ordinary switchboard and portable voltmeters of the permanent magnet type are good for this testing. Most makes of these have a resistance of about 100 ohms per volt of the scale or 15,000 ohms for a 150-volt meter, and if the exact value of r cannot be obtained, this value can generally be used in making tests.

Adjusting Brushes

Unless the generator is shipped completely assembled it is necessary to check the spacing of the brushes. To do this, place a strip of paper around the commutator under the brushes, and mark the position of each set. The strip of paper can then be removed and the distance between marks measured. If the distance varies the brush holders should be moved. The degree of accuracy with which the brushes should be set will depend upon the type of machine; with interpole generators the spacing should be more accurate than with other types of machines. The brushes on a given stud should be staggered with respect to those on the adjacent studs so that the entire commutator will be covered by the brushes, except a slight space at each end. This prevents grooves wearing in the commutator. After the brushholders are set, the brushes need fitting to the commutator. The carbon brushes which are usually used, except upon very low-voltage machines, can easily be fitted by using sandpaper while the machine is still. A strip of sandpaper is placed between the brush and the commutator, and pulled in the direction of rotation while the brush is pressed against the rough surface. The brush should be lifted while the sandpaper is returned, and then dropped down again for another stroke. It is also well to curl the sandpaper slightly so that it will lie close to the surface of the commutator, to prevent rounding over the back edge of the brush. The spring pressure on all the brushes should be the same and just sufficient to insure firm contact with the commutator.

After fitting the brushes, all dust should be blown out of the machine by compressed air from a hose. Too high a pressure should not be used at the nozzle, as it may tear the insulation; a pressure of 50 to 80 lb. per sq.in. is frequently used with a ⅛-in. nozzle. However, this is really more than necessary for cleaning the windings, and when so used the pressure at the nozzle should be reduced by throttling. It is convenient, however, to have a rather high pressure for cleaning out the air ducts in the laminated frame of a machine, where dust saturated with oil often lodges.

The bearings should be cleaned either by taking them apart, or by washing out with gasoline, and then they should be filled with oil to the proper height. If the field of the generator is mounted on a foundation separate from that of the armature, the air gap should be checked with a wedge-shaped gage. It is best to select one point on the armature and gage between this and each pole face, by turning the armature over as required.

The brush-holder rigging should be rotated until the brushes are set in the proper running position. In all except interpole generators the brushes are given a forward lead, that is, are moved in the direction of rotation a slight distance from the neutral point. Generally the neutral point is marked by the manufacturers, and is where the brushes will be approximately opposite the centers of the main poles. If not marked, it can be determined, if the armature conductors can be traced out to their connection with the commutator. If the two sides of a coil span the whole distance between adjacent poles, that is, if the throw of the coil equals the pole pitch, the brushes would be on the neutral point when they short-circuit the coil which is exactly midway between the poles. If the throw of the coil is less, the neutral position of the brushes must be approximated as closely as possible. With interpole generators, the brushes should generally be set on the neutral point, or in some cases may be given a very slight forward lead. A forward lead makes the generator more stable when operating in parallel with other machines, but reduces the compounding somewhat.

Grounds and Drying Out Generator

Before starting the generator it is best to test for grounds, particularly in 500-volt machines. A magneto may be used if nothing better is available, but would only indicate a bad ground and is not satisfactory. If direct current is available, it is desirable to test for grounds with a voltmeter, using the method previously described. Ordinarily, if the machine is in proper condition, the voltmeter will not deflect appreciably; anyway an insulation resistance of 1,000,000 ohms would be sufficient. A reading of the full supply voltage would indicate a "dead ground," or an actual metallic circuit from the windings to the frame. In a new machine, this would probably be caused by a mistake in erection, or by some damage to the insulation. The cause of this ground should be discovered and removed. A voltmeter reading less than full-line voltage indicates low insulation resistance, but no complete ground. This may be due to dirt on the insulation of the brush-holder parts or terminal blocks. If no trouble is apparent here, probably the insulation is damp and the machine should be dried out.

To do this, the generator should be run with the armature short-circuited beyond the ammeter and circuit-breaker, or fuses, and the current in the shunt-field circuit adjusted to give approximately full-load current. With a compound-wound machine, the speed may have to be reduced for this run to limit the current. The temperature of the parts of the windings which are accessible should not be allowed to exceed 160 deg. F., and the current should be adjusted to maintain this temperature. Tests of the insulation resistance should be made at intervals during the drying-out run.

As the machine heats, the insulation will test lower than when cold, but after a time the resistance will increase, and when thoroughly dry will remain practically constant as long as the temperature remains the same.

When the generator is ready to operate, the main switch should be opened and all the field resistance cut in; then the generator can be started slowly. The oil rings should be inspected to see that they revolve freely, and the machine can be brought up to speed. The voltage may now be gradually raised to normal, by cutting out resistance in the field rheostat, noting, as this is done, any tendency to sparking at the commutator. If sparking occurs the brushes should be shifted slightly until it ceases.

Reversed Polarity

The polarity of the generator should next be checked. If the new generator is to be put in service with machines already in use, the polarity of the busbars is fixed. If a voltmeter is available, two temporary leads may be connected to it and the instrument used for checking the polarity before closing the main generator switch for the first time. The voltmeter leads should first be attached to the busbars, noting which, when connected to the positive lead of the voltmeter, deflects it to the right; this is the positive bar. The generator leads at the switch terminals should be tested similarly, and the positive terminals determined.

If the connections cannot be checked this way, a simple test may be made as

shown in Fig. 2. The switch *S* should be open, the circuit-breaker *C* closed and incandescent lamps connected between the switch terminals. For a 125- or 250-volt system, a single lamp of the same voltage should be used on each side. For higher voltages enough lamps should be placed in series so that the sum of the voltages of the lamps on each side will approximately equal the voltage of the system. If the polarity of the generator is correct, the voltage of the generator will be opposed to that of the busbar and the lamps will not burn. If the polarity is reversed, the two voltages will be added and the lamps will burn brightly. It is assumed that the connections between the generator and main switch have either been traced out, or tested with a bell and buzzer, or by some other method, so that the equalizer terminal and the other two terminals of the generator can be identified. As previously pointed out, the series windings must be in parallel, hence the proper connection of the generator leads at the main switch is fixed. If the polarity of the generator is reversed, it cannot be corrected by reversing the leads, but the polarity of the generator must be changed, usually by reversing the residual magnetism of the field. To do this, all the brushes should be lifted clear of the commutator, leaving no circuit through the armature. The generator circuit-breaker should be opened and its terminals shunted by a small fuse. Upon closing the main switch the field will become magnetized in the proper direction by current from the busbars. Before opening the main switch, the field rheostat should first be all cut in to reduce the current as much as possible, and then the circuit should be opened slowly by the main switch. These precautions should be observed particularly on large or high-voltage machines, otherwise the field winding will be subjected momentarily to a very high voltage. If the field magnetism cannot be reversed by current from the busbars, the necessary changes may be made sometimes at the generator. The brushes should be moved a distance corresponding to the space between adjacent poles and the terminals of the shunt and series fields reversed.

Sometimes, in starting a new machine, the voltage will not build up when the field rheostat is cut out. This is usually due to a poor contact in the field circuit caused by a loose connection, or dirt on the commutator. Sometimes the brush pressure can be increased on two brushes of opposite polarity by pressing them down until the voltage starts to build up. If this is not effective the whole field current should be examined for a loose connection or imperfect contact, not forgetting the connections between the field coils. If the machine still fails to generate, the terminals of the shunt field should be reversed, as it may be connected so that it tends to build up in opposition to the residual field. If this is ineffective, the connections should be made as originally. If other machines are available, the generator field can be magnetized as described for correcting reversal of polarity.

A voltmeter, if available, can be connected across the armature terminals to measure the voltage due to the residual field. With the shunt-field circuit open, the voltmeter should indicate several volts. Loss of magnetism is rare, however, and can be restored by exciting the field from the busbars. It is always advisable to see that the shunt and series coils are properly connected. To do this, the voltage should be raised to normal and then some load placed on the machine. The voltage should be noted, and then the terminals of the series coils short-circuited. If the voltage drops, the connections of the series coils are correct; if it rises, the connections are wrong and should be reversed.

Putting Generator on the Line

When preparing to put a shunt-wound machine in parallel with other machines

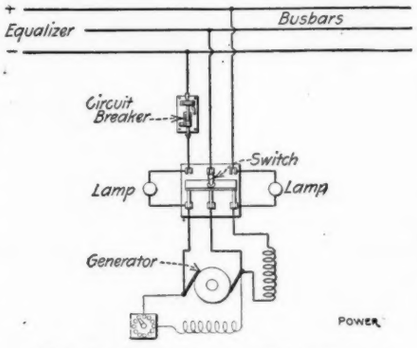

Fig. 2. Testing for Polarity of Generator

which are in service, the circuit-breaker of the incoming machine should be closed and the voltage made slightly higher than that of the busbar. Then the main switch can be closed and the field rheostat adjusted until the generator takes its share of the load. With compound generators, where single-pole switches are used for the positive, negative and equalizer leads, the two switches connected to the series field should be closed first. The shunt-field rheostat is then adjusted until the voltage of the incoming machine approximately equals that of the busbars; then the remaining switch can be closed. The shunt-field rheostat can then be adjusted until the incoming machine takes its share of the load. If a three-pole main switch is provided, the voltage of the incoming machine should be made a few volts higher than the busbar voltage, after which the switch can be closed and the field rheostat adjusted to give the proper load. If a new compound or interpole generator will not take its share of the load, the machines should be tested separately to see that they give the same voltage for corresponding loads, and, if necessary, the shunts on the series coils should be adjusted so they will.

After the machine has run satisfactorily for a short time, the load may be shifted from the other machines to the new one until 25 per cent. overloaded.

Switches and Feeders

The instruments on the switchboard should be checked as far as possible. All voltmeters should be compared by placing on the same voltage. Watt-hour meters should be checked to see that the disk is rotating in the proper direction. If an ammeter appears to be in error, the connections from the shunt to the meter should be examined for loose connections and to make sure that the serial number of the shunt and the meter are the same.

If new feeders are to be put in service they should first be tested for grounds and short-circuits. Grounds or partial grounds on short feeders can be detected with a magneto, but more satisfactory is to use a voltmeter as previously described. When using a voltmeter, lead (*B*), Fig. 1, should be grounded and lead (*A*) connected to the feeder. The allowable insulation resistance depends upon the character of the feeder. The National Board of Fire Underwriters requires completed wiring, exclusive of sockets and receptacles, to have a resistance of 200,000 ohms for a system of 100 amp. capacity, 50,000 ohms for 400 amp. and other capacities in proportion. This includes all branch wiring, so that a single feeder should have a much higher insulation resistance. Underground feeders should, in general, have a high insulation resistance. An overhead feeder or an underground feeder connected to a third-rail system would have a rather low insulation resistance. A bank of lamps may be used to test this class of feeders, since high insulation resistance is not necessary.

Storage Battery

After a storage battery has been erected, it requires a special forming charge before being put in regular service. This charge usually requires from 40 to 50 hr., but need not be continuous after the first 12 hr. Care should be taken to have the positive terminal of the charging circuit connected to the positive terminal of the battery. The acid should not be placed in the cells until ready for the forming charge. A large amount of gas is given off near the end of this charge and for this reason the battery room should be thoroughly ventilated and no flame brought near the cells as the gas sometimes forms an explosive mixture with the air. The rate of charge is specified by the manufacturers and generally starts at a value somewhat greater than the 8-hr. discharge rate, and is decreased as the charge proceeds.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

American Practice in Rating Internal Combustion Engines—III*

By T. C. Ulbricht and C. E. Torrance, Jr.

American Fuel Oils and Gases

To complete the tables of data as given by the manufacturers, the authors found it necessary to collect all available information on the analyses of American fuel oils and gases, the average values of which are shown in Tables 1 and 2. To make this as complete as possible, a brief description is here given of each type of gas used for power puposes, taken in the same order as found in the tables.

All results in the tables, which are inclosed in brackets, represent inserts by the authors as a result of their best judgment for the case considered.

The latest determinations of heating values that could be found were used in checking the data given by the various analyses, for higher and lower calorific values. After careful checking with several American and German authorities, the values given by Levin, were selected as the standard with which to compare given calorific values, both high and low.

Power Gases

All power gases contain more or less hydrogen, in addition to hydrogen gases, the latter being combinations of hydrogen and carbon in various ratios. Over 200 hydrocarbon compounds exist in gaseous, vaporous liquid and solid states. The gaseous forms are known as fixed, or permanent gases, since these do not condense to form tarry liquids and sooty deposits when subjected to a reduction in temperature, as do the various compounds.

The two principal hydrocarbon gases are methane or marsh gas (CH_4) and ethylene (C_2H_4). Both give off considerable heat during combustion and require more air than does hydrogen to insure complete combustion with oxygen. The products of combustion are water vapor and carbonic-acid gas. The compounds of carbon and oxygen are carbon dioxide (CO_2)) and carbon monoxide (CO). The former is inert and therefore valueless for power purposes, and merely dilutes power gases, so that designers always attempt to obtain as little as possible. Carbon monoxide, however, is an active gas, and has the power of combining with oxygen.

Therefore, since the inflammable gases are composed of several gases, both combustible and noncombustible in varying ratios, they are not of equal value as far as power production is concerned. Yet when mixed with air in such proportions as will permit proper control of explosions and greatest efficiency when burned within gas-engine cylinders, the amount of heat produced per charge does not differ greatly.

For instance, natural gas may evolve from 800 to 1000 heat units for every cubic foot of air, while producer gas will produce from 120 to 150 heat units under similar conditions. Yet in practical gas-engine work, it is necessary to dilute the natural gas so that only about one-tenth of the charge is combustible, while the producer gas needs only a little more than its own volume for dilution. Thus, whatever power gas is used, the amount of power produced per explosion is practically the same.

To produce an ideal power gas, the following points, as noted by J. R. Bibbins, should be observed:

1. Cheapness of generation.
2. Simplicity of operation, for which reason the recovery of the byproduct should not be undertaken by plants, unless they are engaged in the manufacture of crude or refined chemicals.
3. A continuous process.
4. A low percentage of hydrogen and inert gases should be obtained.
5. Because of higher compression in engines, etc., a clean gas, free from dust and other foreign substances is essential.

Producer Gas

This is the name applied to the group of gases which are similar in composition, but vary in the proportions of constituents, that are generated by passing air or a mixture of steam and air, through an incandescent bed of carbon.

When a producer is working normally, there is generally a thin bed of ashes on the grate; on top of this is a deep bed of incandescent fuel, and above this a layer of fuel that has not attained such a high degree of incandescence. The gas is produced by drawing or forcing air through this incandescent bed. With air alone, however, the temperatures become excessive, and the tendency is to generate a superfluity of carbon dioxide (CO_2). To counteract this steam is introduced into the air blast, and serves to absorb the surplus heat while decomposing, and to enrich the gas with hydrogen; also additional oxygen is furnished for the gasification of the carbon. Dowson, Riche, Mond, Siemens, etc., are familiar names for gases in this class that are similar in character.

Illuminating Gas

This is made by three distinct methods:

a. Water gas—resulting from passing steam through a bed of incandescent carbon (coke), which has first been raised to a high temperature by a forced blast of air. The process is intermittent, and the gas burns with only a pale-blue light.

b. Carbureted water gas—produced much the same as plain water gas, except that oil is added, sprayed into the water gas to give it illuminating properties. This process is also intermittent.

c. Coal gas (bench gas)—which is the result of heating bituminous coal in air-tight retorts. The volatile constituents of the coal are driven out by being subjected to great heat for about six hours, and are passed through various washing and purifying processes.

Natural Gas

Natural gas is obtained from the interior of the earth, in various parts of the world, but especially in the neighborhood of oil fields. Its chief constituent is marsh gas (CH_4), with small amounts of hydrogen, carbon monoxide and unsaturated hydrocarbons. This gas is well adapted to gas-engine use, and is devoted to this purpose extensively in the natural-gas regions around Pittsburgh, Buffalo, Indianapolis and throughout Ohio.

Blast-furnace Gas

This gas is given off from cupolas, used in the production of iron and steel. To make pig iron, the ore is treated in a blast furnace, with coke or anthracite coal and some kind of flux. Some of the fuel is burned by an air blast, and as a result of this heat, the balance unites with the oxygen of the iron ore, leaving more or less pure iron. The gas given off contains from 20 to 34 per cent. of carbon monoxide, some hydrogen and hydrocarbons, from dissociation of water and volatile matter in the fuel, some carbon dioxide, and much nitrogen. Blast-furnace gas is always weak, because of the small amount of CO, and requires a much larger cylinder capacity for a given power than other gases. However, under cer-

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TABLE 1. AVERAGE ANALYSES OF AMERICAN GASES

Gas	Average Constituents of Gas—in Per Cent. Volume									Theoretical Calorific Value per Cu.Ft. of Gas at 62° and Atmospheric Pressure B.t.u.		Calorific Value per Cu.Ft. by test B.t.u.		Theoretical Air per Cu.Ft. Gas	B.t.u. per Cu.Ft. of Mixture		Calculated B.t.u. per Cu. Ft. of Mixture-Theoretical Air		Calculated B.t.u. per Cu.Ft. Mixture—Excess Coef.-as Below-				
	CO_2	CO	H	CH_4	C_2H_6	C_2H_4	C_6H_6	N	O	High	Low	High	Low		High	Low	High	Low	1.1	1.2	1.3	1.4	1.5
Producer																								
Anthracite	6.03	22.38	13.38	1.96	.....	0.36	....	55.65	0.803	138.4	125.7	142	131.3	1.053	67.9	64.1	67.5	61.3	58.2	55.4	53	50.8	48.7
Bituminous	9.12	17.54	11.73	4.28	.....	0.36	....	57.24	0.265	137	125	154	136	1.120	(72.7)	47.8	64.6	59.0	56	53.4	50.8	48.7	46.6
Coke	4.90	27.30	10.07	1.18	.....	.....	....	56.60	0.550	128.7	126.3	133.7	(125)	0.985	(67.4)	(63)	65.0	63.7	60.7	57.8	55.4	53.1	51.0
Lignite	9.43	18.90	15.13	3.65	.....	0.424	....	52.50	0.582	144	134	156.4	.....	1.145	(72.8)	.....	67.2	62.5	59.3	56.4	53.8	51.5	49.3
Oil	4.10	11.40	5.57	5.87	.....	3.10	....	66.90	3.060	176	151	.....	.....	0.990	.....	.....	88.4	75.9	72.2	69.0	66.0	63.2	60.7
Peat	12.40	21.00	18.50	2.20	.....	0.40	....	45.50	0.000	153	141	175	.....	1.170	(80.6)	.....	70.6	65.0	61.6	58.8	56.3	53.5	51.2
Wood	13.90	20.03	21.00	2.79	.....	0.60	....	41.80	0.185	137	128.7	138.7	.....	1.070	(67.0)	.....	66.2	62.2	59.2	56.3	53.8	51.5	49.4
Illuminating																							
Water	4.72	34.8	48.81	4.06	.....	1.97	....	7.16	0.503	322.1	304	329	278	2.63	(90.6)	(76.6)	88.8	83.8	78.0	73.2	68.8	64.8	61.5
Carbureted Water	2.07	24.1	32.40	23.40	.....	12.52	....	3.75	0.510	646.4	589	677	632	6.84	99.1	90.94	82.4	75.1	69.0	63.9	59.5	55.7	52.3
Coal or Bench	1.21	6.18	43.94	37.78	.....	5.87	4.16	3.50	0.502	677	608	655	592	6.00	97.8	86.40	96.7	86.8	80.0	74.2	69.2	64.7	60.8
Natural																							
Average	0.684	0.647	10.89	79.67	.....	1.26	6.40	5.89	0.79	948	853	965	855	9.85	96.2	87.2	95.2	85.7	78.5	72.7	67.5	63.0	59.1
High Hydrogen	0.580	0.730	20.56	50.30	.....	2.07	5.88	8.80	1.13	923	834	895	810	8.66	(92.6)	(83.8)	95.5	86.3	79.2	73.1	68.0	63.5	59.5
Low Hydrogen	0.800	0.525	1.92	91.40	.....	0.515	....	3.25	0.50	967	870	971	862	9.20	96.2	87.2	94.7	85.2	78.3	72.4	67.1	62.7	58.8
Blast Furnace	11.80	26.75	3.40	0.30	.....	.....	....	58.8	0.182	98.7	95.2	98.7	.....	0.735	55.3	51.8	56.8	54.8	52.7	50.5	48.6	46.8	45.2
Coke Oven	2.1	6.51	51.56	32.9	(1.4)	2.5	....	4.0	0.36	577.0	487.0	598.0	506	4.76	96.7	84.0	100.0	84.5	78.2	72.4	67.8	63.5	59.8
Oil Gas	2.79	4.96	17.70	23.60	18.78	5.53	....	37.55	0.702	595.0	542.0	662.0	.....	4.94	(111.3)	.....	100.0	91.2	84.2	78.2	73	68.4	64.4

TABLE 2. AVERAGE ANALYSES OF AMERICAN FUEL OILS

	Baumé Gravity Scale	Specific Gravity	Per Cent. C	Per Cent. H	Calorific Value per Lb. B.t.u. Calculated B.t.u.		Calorific Value per Lb. Actual by Test B.t.u.		Theoretical Air Cu.Ft. per Lb.	Calorific Value per Cu. Ft. of Mixture	Theoretical Air B.t.u.	O Plus N	Per Cent. N	Per Cent. O	Per Cent. S	Calorific Value per Cu.Ft. Mixture (Low) Calculated with Given Excess Coefficient, B.t.u.					Boiling Point	Flash Point
					High	Low	High	Low								1.1	1.2	1.3	1.4	1.5		
Gasoline	70.2°	0.704	82.54	14.91	21,271	19,818	19,740	18,500	193.5	109.2	102	4.3	1.93	0.31	0.09	93	85.2	78.8	73.2	68.2	176°	55
Kerosene	47°	0.863	84	14.14	20,892	19,600	20,849	18,755	189	110.3	103.6	2.3	1.838	2.0	0.23	94.3	86.3	79.7	74	69	437	130
Crude oil	18.3°	0.877	84.24	13.44	20,162	19,160	19,560	18,636	187	111.7	102.3	3.1	0.2	1.93	0.823	93.2	85.3	78.8	73.1	68.2	..	..
Fuel oil	..	0.939	83.04	11.58	19,183	18,138	19,121	..	178	110.2	102	..	0.60	2.82	0.90	92.7	85.0	78.5	73.0	68.2	..	..

tain conditions, its use has resulted in a marked economy.

Coke-oven Gas

This is produced in large iron and steel works, from the furnaces or ovens used in producing coke for smelting processes. It is similar to the illuminating gas known as coal gas, and in both cases the tar and liquor produced during the purification process, results in the recovery of valuable byproducts.

Oil Gas

Oil gas is the result of heating crude petroleum, refined petroleum or any other oil composed of hydrocabons, in a closed retort, so that "cracking" results, and hydrocarbons which are gaseous at atmospheric pressure and temperature are obtained. By properly regulating the time and temperature, the process of decomposition can be stopped at any desired point. Thus, liquid hydrocarbons may be decomposed into liquid hydrocarbons of less density, and further heating decomposes these into gaseous hydrocarbons, which process is termed "cracking." Oil gas is not the same as vaporized oil, since in the latter the hydrocarbons are unchanged, and if the vapor is cooled, a liquid will result.

Calorific Values of Fuel Gases

All computations for the calorific values of fuel gases are taken for the lower heat values. The standard formula for the calorific value is:

$$H_v = (\text{——})\ CO + (\text{——})\ H + (\text{——})\ CH_4 + (\text{——})\ C_2H_6 + (\text{——})\ C_2H_4$$

the symbols representing the percentages of the constituents in the gas. After careful checking with German and American authorities, the following values in B.t.u. per cubic foot (lower value) at 62 deg. F for the constants in the foregoing formula were selected as giving the heat value:

$$H_v = 324\,CO + 275\,H + 910\,CH_4 + 1620\,C_2H_6 + 1512\,C_2H_4.$$

As will be noted from table 1, no matter what gas is used, the heat value per cubic foot of mixture is very nearly the same. This is because of the variation in the quantities of air required to burn the different gases. For instance, a gas with a low heat value, would normally give a low horsepower for a given size of cylinder. The air required to burn this, however, is less per cubic foot, so that more gas is taken into the cylinder and more heat units are liberated.

Liquid Fuels

The liquid fuels comprise crude petroleum and various tarry residues, which consist principally of combinations of carbon and hydrogen, together with comparatively small amounts of nitrogen, oxygen and sulphur. Taking hydrogen and carbon as the main constituents, it is found that those oils which are rich in the former element have a light specific gravity, as compared with those rich in carbon. The range of specific gravity of California oils may be taken from unity to 0.84 or from 10 to 36 on the Beaumé scale. The majority of fuel oils will range from unity to 0.9 or from 10 to 23 Beaumé.

The Beaumé scale bears the following relationship to specific gravity.

$$Specific\ gravity = \frac{140}{130 + B}$$

or

$$B = \frac{140}{specific\ gravity} - 130$$

The calorific value of liquid and solid fuels can be computed by Du Long's formula, in which the most approved heat values (low) have been used. This is:

$$\text{Calorific value} = 14{,}600\,C + 52{,}275\,(H - O/8) + 4050\,S$$

where H, C, O and S represent respectively the percentages of hydrogen, carbon, oxygen and sulphur.

CORRESPONDENCE

Tar Troubles with Producer Gas

One of our troubles in the operation of bituminous producers is the filling up of the horizontal runs of pipe between the vaporizer and the scrubber with a compound of tar and soot, which is too thick to flow. This apparently gathers on the upper half of the pipe until it becomes heavy enough to break loose and fall to the bottom, there building up until the passage is so restricted that the generators must carry 2 or 3 in. pressure.

Removing this is hard and uncomfortable, and precautions must be taken to prevent the men from being overcome by

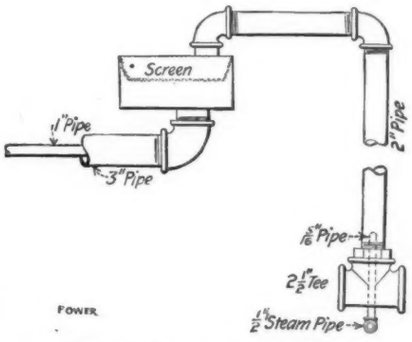


Fig. 1. Tar Elevating Jet

the gas. Even with the passage to the generator closed, enough gas will remain in the pipes and apparatus to overcome a man, and this dead gas seems to be more poisonous than when the plant is in operation. The tar which was not exposed to the air also seems to give off a poisonous gas.

To avoid accidents when doing this or similar work, it is best to induce a circulation of air through the piping by a fan or blower. The least it has cost us to clean the two pipes, each 25 or 30 ft. long, has been $14.50, and this is only one of the various items of expense that go to make up the cost of producing gas from bituminous coal.

We put a 1-in. steam pipe in the gas lines, hoping to be able to warm them up and blow the tar over into the scrubber where it would be easier to remove. We

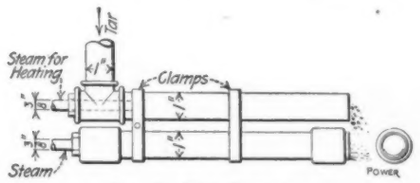


Fig. 2. Tar Burner

are doubtful, however, as to its effectiveness. We find it necessary to run steam pipes to all the main gas valves to warm the tar in order to be able to open them when starting. Also all separating and tar wells, as well as pipes carrying tar, have to be provided with steam pipes and heating coils. Exhaust steam is used wherever possible, but at the same time considerable live steam is used and the available heat from the tar that we are able to save and burn for steam making amounts to not more than 30 per cent. of the heat necessary for this purpose.

We tried handling the tar with pumps but found it too thick and dirty, and were beginning to despair of a way out of the difficulty when we thought of blowing it through with steam. Fig. 1 shows the device used. The tar flows in by gravity, and, after being heated by the steam, is forced up through the pipe. The tar requires large free openings up to where the steam is applied. Where the jets discharge from the separating wells to the receiving well, we have placed a strainer box to catch the lumps of soot which, if not strained out, would cause trouble.

From the receiving well the tar is elevated about 12 ft. above the burner at the boiler, which is 100 ft. away, and to which it is conveyed through a 3-in. pipe, having a 1-in. steam pipe inside. The tar makes an intense flame, hence must not be too close to the shell. We have overcome this by dropping the grates 4 ft. below the shell, at which point the tar burner enters from the side. Also a small coal fire is kept on the grates to ignite the tar if the burner becomes temporarily clogged and the flame goes out. This burner, as shown in Fig. 2, is very simple, being made of pipe and fittings.

A burner having small openings is useless with producer-gas tar. If our burner becomes plugged, opening the regulating cock wide for a few seconds will pass the lumps through.

J. O. Benefiel.

Anderson, Ind.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

The Heating and Ventilating Engineer

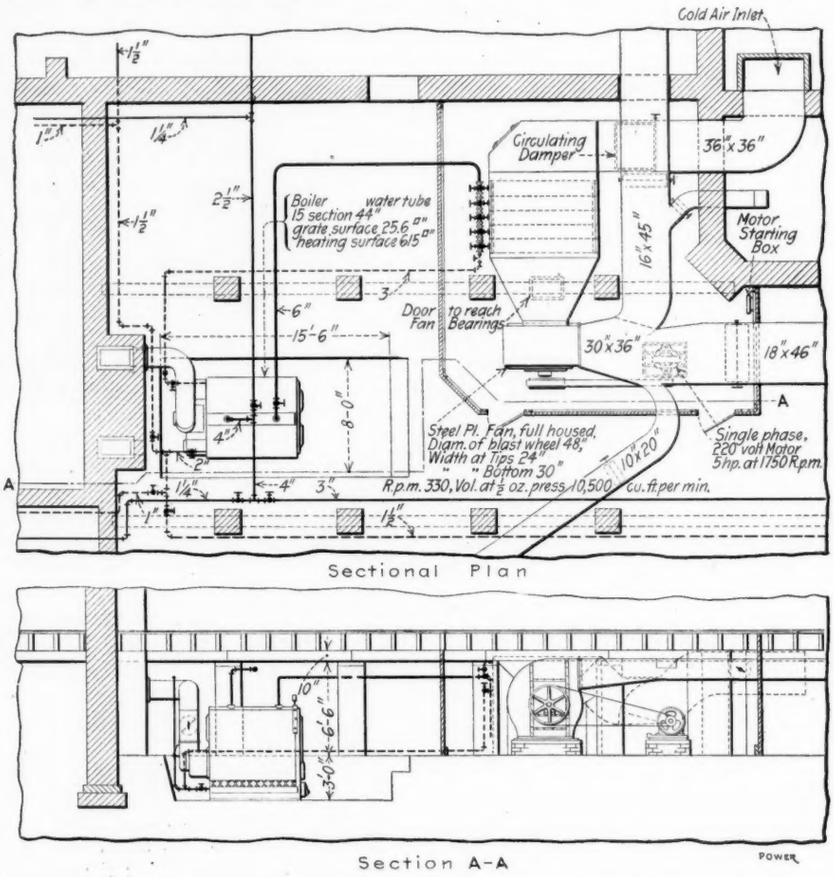
BY J. P. LISK

Under present conditions the work of a heating and ventilating engineer is difficult and unsatisfactory. Generally he is not consulted concerning the construction of the building, but must take it as it is given him, and fit his apparatus to it, avoiding all interference with architectural or constructional features. The apparatus must be ample in size, highly economical in operation and, of course, inexpensive. Any place in the basement or cellar that cannot be used for some other purpose, is generally assigned as the place to put the heating and ventilating apparatus.

Although not generally so understood the equipment is essentially a power plant requiring in its design and installation specialized engineering ability and experience. The foregoing statement is made to correct the prevailing impression that heating and ventilating is a simple side line of either mechanical or electrical engineering and may be picked up and successfully applied by any bright assistant in the office.

Doubtless as the price of fuel advances more attention will be given to the design of heating and ventilating installations, based on the economy of operation rather than the economy of installation, now so painfully apparent to the occupants of underheated apartments, and to the heating contractor who would like to do good work but cannot on account of the prices owners are willing to pay for this very essential part of their building equipment.

The reason that ventilating systems fail to work is that they are not worked. An occasional private owner and generally municipal authorities will employ a competent engineer to design a heating and ventilating system, have it installed, pay for it, and after they have learned by one season's experience that it costs money to ventilate a building, they have the ventilating part of their system put out of commission and blame the engineer for not providing a more economical plant.


Cold Air Inlet
Circulating Damper
36"x36"
Boiler water tube
15 section 44" grate surface 25.6 □' heating surface 615 □'
16"x45"
Motor Starting Box
Door to reach Fan Bearings
30"x36"
18"x46"
15'-6"
8'-0"
Steel Pl. Fan, full housed, Diam. of blast wheel 48", Width at Tips 24" " Bottom 30"
Single phase, 220 volt Motor 5 hp. at 1750 R.p.m.
R.p.m. 330, Vol. at ½ oz. press. 10,500 cu. ft. per min.
Sectional Plan
Section A-A
POWER

A TYPICAL HEATING AND VENTILATING PLANT DESIGN

Without question there are many engineers in this country and in Europe who are perfectly competent to design systems for heating and ventilation to meet the requirements of any public or private building in temperature, humidity, volume and purity of air supply as prescribed by physicians and sanitary experts. Unfortunately, there are no legally fixed standards, either municipal or state, for volume or purity conditions to guide the engineer. This statement is made with full knowledge that there are certain sections in New York State laws and also in the New York City charter which mention ventilation but give absolutely nothing to guide the heating and ventilating engineer. He is still obliged to assume the prerogatives of the state and municipal authorities and physician when he is called upon for service and is expected to render a quality of service that will bear inspection by the most critical.

There should be fixed standards of ventilation for every class of public building. Sanitarians should determine what would be reasonably good hygienic conditions to maintain. The various societies interested could influence the passage of laws embodying the necessary standards. The engineer could then lay out a system to fulfill the required conditions with some degree of satisfaction.

The engineer is not a physician, nor a sanitarian, but he is perfectly capable of fulfilling conditions prescribed by either. If the public had some definite standard by which to measure his work, they would know what they were getting, and general satisfaction would undoubtedly prevail.

The following shows that it is easy to obtain desired results even in a small plant with fixed conditions to meet. A building for which the author designed and installed a hot-blast heating and ventilation system, contained several auditoriums, the seating capacity of which totaled 675 and the longest period of occupancy was two hours.

The net volume of the combined auditoriums was 121,700 cu.ft. The temperature to be maintained within the building, with an outside temperature of zero, was 65 deg. F. A sanitary expert specified 900 cu.ft. of air per hour per seat, which was to be delivered hot enough to in-

sure a temperature of 65 deg. in the rooms.

The total volume of air would be

675 × 900 = 607,500 *cu.ft. per minute*

The heat lost by ventilation, the air being discharged through the vent flues at a temperature of 65 deg. F., was estimated to be 13,163 B.t.u. and the heat lost through walls and glass 11,645 B.t.u., making a total of 24,808 B.t.u. per minute, to be supplied by the apparatus.

With a fixed volume of 10,125 cu.ft. it was necessary to deliver the air at 120 deg. F. at the inlet register to maintain the desired temperature of 65 deg. in the auditoriums. The room construction was such that the air could be delivered most advantageously 10 ft. above the floor, which permitted a delivery velocity of 6000 ft. per minute without inconvenience to the occupants.

From the above data the size of the necessary apparatus can be determined. This includes a boiler to generate the steam, a radiator to transfer the heat to the air, a fan to move the air and an electric motor to turn the fan.

Formulas based on 12 years' experimenting and testing apparatus installed by the author and checking by installations of other engineers under working, not theoretical, conditions follow: The symbols used are given first.

A = Volume of air in cubic feet per minute passing through heater under ordinary barometric and humidity conditions at sea level;

H = Heat units per cubic foot of air to obtain the desired temperature;

U = Latent heat in B.t.u. in one pound of steam at atmospheric pressure = 970.4;

N = Number of four-row sections in one group;

C = Relative condensation per section or group of sections;

V = Velocity of air in feet per minute passing through heater;

R = Constant (0.00125) based on the velocity of the air passing through heater;

F = Square feet of heating surface in the heater;

W = Weight of the water of condensation in pounds;

a = Free area through heater in square feet.

To find the square feet of surface in the heater, use the following formula:

$$F = \frac{\frac{AH}{U}}{VCR} \times 60$$

To determine the pounds of condensation use

$$W = \frac{AH}{U}$$

For the free air through the heater the following formula may be used:

$$a = \frac{A}{V}$$

Applying the formulas to the case in hand, A = 10,125. The temperature of delivery must be 120 deg. F., which requires a five-section heater. The relative condensation of a five-section heater is 1.08 lb. per square foot and the number of heat units required is 2.2 per cubic foot. The total surface in the heater is, therefore,

$$F = \frac{\frac{AH}{U}}{VCR} \times 60 = \frac{\frac{10{,}125 \times 2.2}{970.4}}{1200 \times 1.08 \times 0.00125} \times 60 = 850 \text{ sq.ft.}$$

The water of condensation from this heater will weigh

$$W = \frac{AH}{U} \times 60 = \frac{10{,}125 \times 2.2 \times 60}{970.4} = 1377 \text{ lb.}$$

The free area through the heater is

$$a = \frac{A}{V} = \frac{10{,}125}{1200} = 8.44 \text{ sq.ft.}$$

The size of the heater being determined, it remains to find the boiler power required, size of fan, and motor to drive it. The accompanying plan gives the size of the apparatus installed and pipe sizes. Besides providing for the hot-blast system the boiler was proportioned to care for 1300 sq.ft. of direct radiating surface.

With an outside temperature from 1½ deg. below zero to 1 deg. above, the delivery at the register was 11,200 cu.ft. of air per minute at 124 deg. F. with 5 lb. gage pressure at the boiler. These results go to show that, with given conditions to meet, a system can be designed which will give satisfaction, and besides there is a basis by which to judge the work.

Sectional Steam Heating in Chicago*

By S. Morgan Bushnell

The Illinois Maintenance Co. has operated on a scheme somewhat diverse from that followed by most steam-heating companies. It has installed no plants of its own and, with one or two exceptions, has installed no boilers. It simply contracts to operate boiler plants already installed in buildings, so as to furnish steam for heating and other purposes. It might be thought that the central-station idea was being lost sight of and that a policy of decentralization, rather than centralization, was being adopted. To a certain extent this is true, but it must be borne in mind that the conditions to be met in the central parts of larger cities are radically different from those in smaller towns.

The heating company in the smaller town which conducts a house-to-house business has much in its favor. In the first place, there is a marked difference in economy between the small heating boilers and the large heating boilers of from 300 to 500 hp. found in central stations. Under tests conditions, house-heating boilers of 25 hp. show an average efficiency of from 40 to 50 per cent. Probably under ordinary working conditions the percentage might fairly be assumed at 35. Assuming an average working efficiency on the larger sizes of boiler of 65 per cent., gives a difference of nearly 100 per cent. in favor of the larger boiler.

Furthermore, small residences and stores find it somewhat impracticable to burn soft coal and usually adopt anthracite on account of its comparative cleanliness, reduced danger from explosive gases, and the greater ease of controlling the fire. While there is no great difference in the heat value of anthracite and the better grades of bituminous coal, the anthracite costs fully 100 per cent. more.

Multiplying these two factors together, an ordinary householder will pay four times as much for a given number of heat units produced in his boiler as the central-station manager. This saving would offset a considerable expense through fixed charges on investment, distributing losses, etc., and still leave a margin of profit for the station.

In the business center of a large city like Chicago, however, the conditions are different. The tall office buildings in the downtown section have boilers ranging from 100 to 400 hp. capacity. Their efficiency will probably average at least 55 per cent. They generally have automatic furnaces adapted to use the cheaper grades of soft coal. The only advantage, therefore, to be gained, from the coal standpoint, would lie in the comparatively small difference in efficiency between the medium-size boiler and the very large one. But this is not all. While gaining only a comparatively small amount in efficiency by substituting central-station boilers, the difficulties of steam transmission in a large city, where the streets are already occupied with various other pipes and conduits, make the cost of transmitting the steam very high.

From time to time estimates have been prepared on the cost of installing a large steam-generating plant in Chicago, but thus far no one has seemed to be able to figure out enough profit from operating the larger plant to offset the heavy investment required. It has, therefore, been the policy of the steam company in Chicago to operate steam plants for only a very limited territory, using one set of boilers for a single building or for several adjoining buildings.

In a number of cases several buildings have been connected to one set of boilers, while each building, as a rule, retains its own boiler, or boilers, for use in

*Abstract of paper read before the National District Heating Association, at Detroit.

emergency or in extremely cold weather. Although the company operates some boiler plants for single buildings, these contracts were taken with a view to combining the building with others in the vicinity as soon as contracts could be negotiated.

All the boiler plants are supervised by a first-class operating engineer, who employs the men. This man visits all of the plants daily, watches the general upkeep and the handling of the boilers by the men, and also keeps close account of the coal consumption. He has an assistant, who visits the plants and also acts as an emergency man to assist in any temporarily short-handed plant. This assistant also makes night inspections to see that the night engineers are as strict in performing their duties as the day men.

The company originally operated entirely on flat-rate contracts, furnishing steam to each building at a fixed price per year. This method of selling steam has been unsatisfactory, and the contracts are being changed as fast as practicable to a meter basis. In the smaller buildings ordinary condensation meters are used, while in the larger ones steam is measured at high pressure by St. John meters.

The rates charged are considerably lower than the meter rates in New York and other large cities, due mainly to the company having little or no investment costs on which to figure a return.

Thus far very little steam piping has been done in the streets, most of the work done up to the present time being to connect buildings on opposite sides of a street or alley. As the field of the company's operations gradually extends, a somewhat more elaborate system of street connections will probably be installed, the plan being to shut down some of the plants now running all summer, to cut down the labor cost. More than fifty boilers are now in charge of the company, but probably less than half of them are used at any one time, on account of the method of operation.

The company's experience in operating boiler plants has shown that the average steam plant in a store or office building is operated with considerable waste and that careful superintendence will show economies which, taken together, will amount to considerable. These economies, however, are largely offset by waste on the part of a customer when steam is sold on a flat-rate basis.

The operation of these plants thus far has not been financially successful. The line of work being a comparatively new one, a great many things were to be learned by experience, both in handling the plants and in negotiating with customers. The net loss in operation, however, has been gradually reduced, and the outlook appears more promising now than at any time since it was organized.

Someone has called this system of heating "Heating from Decentralized Plants." This is true only to a very limited extent. The work of the company would more properly come as a division under the head of "District Heating," only the districts are much smaller than those usually served from heating stations. It is expected that as the plans of the company develop, some of these districts will be considerably enlarged and that from year to year additional buildings will contract for their heating from these centers.

For example, in the case of the Insurance Exchange Building on Jackson Blvd. and Fifth Ave., four 350-hp. boilers are now installed. Space has been provided for considerable extension, if desired. The stack and breeching have been designed for a capacity for nearly 3000 hp. Negotiations already have been started to supply some of the surrounding buildings, and as the company has a long-term contract with the building, it will probably be able to connect others to this center. Another typical plant is that of a large department store which, in addition, supplies steam for an adjoining office building and two restaurants.

Running pipes underground has been quite a serious question in the operation of these plants. Apparently, from the nature of Chicago soil, some methods of installation which have given fairly satisfactory service in other cities deteriorate here very rapidly, and it has been found that in a very few years after installing the pipes nothing has been left, but the iron pipe and the concrete. The iron pipe also seems to be attacked more or less, either by acids or electrolysis, and in several cases has had to be replaced or a smaller pipe installed within the original one.

A year ago the company laid an 8-in. pipe line, 300 ft. long, connecting the boilers in the old Edison Building on Market St. to the boilers in the new office building at Madison and Market Sts. for the *Chicago American* and *Chicago Examiner*. Where the line crosses the street it was laid at an average depth of 9 ft. A tile sewer drain was first installed, in gravel, and over this was laid a bed of small rock and sand to promote drainage. This was covered with reinforced concrete, in which roller bearings for the piping were embedded. The pipe was covered with two thicknesses of $\frac{1}{16}$-in. sheet asbestos paper, painted with special tar paint. A dead air space of 1 in. intervenes between the asbestos covering and a paper felt conduit 1½ in. thick lined with sheet tin. About this were two layers of tar felt paper completely covering the line. This also was painted with special tar paint, and outside was a casing of reinforced concrete 3 in. thick.

The operation of the line thus far has been very successful. The steam service has been continuous. No appreciable leaks have developed, and the loss through condensation has only amounted to 300 lb. per hour. As the steam transmitted in cold weather is about 10,000 lb. per hour, a fairly satisfactory efficiency in transmission is obtained.

The connected radiation amounts to less than 500,000 sq.ft., but more than 30 elevators, ice machinery, pumps, hot-water heaters, and other apparatus give a summer load requiring a coal consumption of upward of 2000 tons per month. Thus nearly half the coal consumption of the company is for other purposes than serving radiators, but expressing the steam demands in terms of radiation, the equivalent is over 800,000 sq.ft.

As the large cities grow older and more compactly built up, it is a question as to what extent the theory of combination and coöperation will be applied to the production of heat, light and power in large buildings. Some middle ground may be found between the large central sources of supply and entirely decentralized operation, along the lines of which the greatest economy can be secured. The above scheme of operation is being gradually extended in an effort to discover this middle ground.

CORRESPONDENCE

Radiators Bypassed

Some years ago I had charge of an exhaust steam-heating system that did not give satisfaction. The radiators were all supplied with steam from a common riser running from the basement to the third floor near the center of the building. All of the returns from the radiators were led into a common 3-in. return discharging into a sewer. Although a back pressure of from 10 to 12 lb. was often carried, some of the radiators always remained cold.

The trouble was that the steam passed from the riser through the nearest radiators to the return and never reached the radiators near the ends of the building. Air valves on the radiators did but little good. I made a dead-weight safety valve out of an old globe-valve, put it in the return pipe and set it to open at about 5 lb. This did very well as a substitute for a trap, and from 2 to 3 lb. back pressure was all that was required.

J. H. CAMPBELL.

Bloomington, Ill.

In too many cases the engineer and manager are intellectual and moral strangers to each other, even after years of close association. The manager can do more to promote intellectual acquaintance than the engineer and it will in most cases pay to make the effort. Some have said that "friendship and business cannot mix"; maybe not, but pleasant relations most certainly lead to mutual good will and confidence, the basis of a successful business of any kind.—*Ice.*

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POWER

Turbine Classification

Ask "What is a spiral stairway?" and it is ten to one that the person addressed will indicate, with a helical movement of his finger in the air, his conception of the structure, before he can get it into words.

Ask an engineer "What is a Curtis turbine?" and ten to one his fingers will interlock in imitation of the active and reversing blades of this type. He will explain that the Curtis turbine is a "velocity-stage" machine in which the steam is expanded in nozzles until it attains a high velocity, and that this velocity is abstracted in two or more stages or steps by allowing the steam as it emerges from the nozzle to impinge upon a blade moving at a velocity considerably less than one-half that of the jet, so that it leaves the blade with considerable residual velocity. The latter is utilized by turning the jet through a stationary or reversing blade so that it is flowing again in the direction of the rotating vanes upon which it is allowed to impinge with a further abstraction of its velocity.

When the velocity induced by its expansion in the first set of nozzles is sufficiently abstracted the steam is allowed to expand to a still lower pressure, restoring its velocity which is again abstracted in two or more stages. This is continued until the condenser pressure is reached, the designer seeking to divide the work equally among the several pressure stages, which will be greater in number as the difference between the initial and condenser pressures is greater, and as the peripheral speed of the vane is less.

The Curtis turbine is therefore a combined pressure-stage and velocity-stage turbine.

Not necessarily. Almost everybody thinks so, and that is the way the type is ordinarily built; but Curtis' patent calls for *one or more* velocity stages for each pressure stage, and the Algemeine Elektricitäts Gesellschaft builds them with several velocity stages in the first-pressure stages, but with simple rotors with one row of blades in the subsequent stages, which thus become similar to those of the Rateau or Zoelly machine. But the Curtis patents antedate those of Rateau and the courts are now busy deciding whether any impulse turbine divided into pressure stages does not infringe them.

Ask an engineer "What is a Parsons turbine?" and one hundred to one he will tell you it is a combined impulse and reaction turbine. The steam is expanded in the stationary blade passages and discharged into the moving blades driving them by its impact. It is further expanded in the moving blades themselves, so that it is shot backward with an increased velocity. The velocity of the jet relatively to the casing or ground is thereby decreased, and the energy equivalent to the difference in that relative velocity when it enters and leaves the blade is left in the rotating member, in addition to that imparted by its impact.

This is the popular conception of the Parsons turbine, and is in fact the way it is ordinarily built. But reduced to its lowest terms and greatest efficiency the Parsons turbine is a pure reaction machine. A nozzle is very efficient; 90-odd per cent. of the energy represented by the heat fall involved in the expansion will be present as kinetic energy in the jet issuing from a properly designed nozzle. The impulse bucket is less efficient. There is loss in the jet between the nozzle and the blade, there is loss by impact and friction and eddies, so that the energy expended in rotative effect is a less proportion of that inherent in the steam than is that from the moving reaction nozzle.

The ideal Parsons turbine, then would not be a combined impulse and reaction, but a pure reaction machine. The steam would be expanded in the stationary blades only until the component of its velocity in the direction of the blade movement was equal to the blade velocity, and it could get aboard without shock or impact, as one runs until he acquires the same speed as a moving train

and then swings aboard as though he were a part of the moving mass.

This would require either a very high blade velocity or a small pressure drop at each stage, which, in turn, means a great number of stages. For ordinary commercial conditions the designer is obliged to allow the steam to enter the buckets faster than their motion, and thus, to some extent, to act by impulse.

The Power Situation

It is reported that Francis S. Peabody, acting for the Commonwealth Edison Co., of Chicago, is about to effect a great combination of coal-mining interests of central Illinois, preparatory to one of the greatest, if not the greatest, centralized system of power production ever planned.

After the mining interests merger, it is planned to erect a huge power plant at Kincaid, Christian County, from which current will be supplied to all the Commonwealth properties, including those in Chicago. Kincaid was selected on account of the water power available there. A part of the plan is to merge all, or at least nearly all public-service plants in the state.

This announcement, quickly following that of the proposed Lehigh Navigation Electric Co.'s 100,000-kw. plant, eventually to be built at Hauto, Penn., and the huge Southern power developments involving in one case a capitalization of $120,000,000, is indicative of a veritable revolution in power generation, and it is all most commendable in that it will undoubtedly mean cheaply produced power and a great reduction of our annual coal consumption. But will it mean a relatively cheaper power to the consumer? That is the vital question.

Recent testimony given before the Maryland Public Service Commission revealed that a hydro-electric power company realized a revenue of $125,000 annually from current sold to a copper works at ½ cent per kw.-hr. The city of Winnipeg, Manitoba, now sells current for lighting at a base rate of 3⅓ cents, with discounts ranging from 10 to 60 per cent.; for heating and cooking (separate meter service), 1 cent, and for power from 3⅓ cents to 0.08 cent per kw.-hr. It is said that highly suitable returns are realized on these rates. These cases are exceptional, but they show what is actually possible with a fair return on the investment. We hope the consumer will enjoy an equitable share of the benefits to be gained by such centralization of power as is now going on throughout the country.

Electrification of Railroads

The steam-locomotive engineer's attitude toward the electric locomotive, as evidenced at the Manhattan Beach conference, recalls the antagonism of the old stationary engineers to steam turbines and gas engines. Of a truth they were "stationary" engineers, but something better might have been expected of "locomotive" engineers.

Progressive engineers, of either calling welcome each advance in their respective fields and further it. Attempts to hinder it are evidences either of fear or prejudice, and certain to have their reward in the obstructors being left at the side of the road of progress blinded by the dust of the passing show. Such is the fate of the "standpatter."

The locomotive engineer is fighting for the sole right to operate electric trains of either the traction or multi-unit type, although in the same breath he protests against their existence—a philosophical acquiescence to the inevitable. We admire his common sense.

The electrification of roads is growing fast. By 1913 the New York, New Haven & Hartford R.R. will have about 552 miles electrified. The Southern Pacific Co. will shortly spend $8,000,000 on such work in and around Portland, Ore. The Pennsylvania extensions are well known. Elaborate experimental work is now being carried on near Toulouse, France, on the Midi Ry. On the Lauban-Konigszelt line of the Prussian State Ry., many miles will be electrified following experiments to determine operating and maintenance costs. A saving of 15 per cent. is expected. The mileage cost there for electric locomotives is said to be $3.73 per 100 miles against $11.20 for steam. The shop maintenance cost is $23.20 per 1000 miles against $60.48 for steam locomotives. England and Germany are also rapidly developing electric railways.

All this will require large power plants equipped with modern units for generating high-tension current, and highly competent engineers will be in demand to operate them. It is a development, therefore, that is likely to be watched with interest by readers of POWER.

Shorter Cutoff Greater Load

The engineer who is accustomed to see the cutoff on the high-pressure cylinder grow later as the load increases, and who knows in a general way that the greater load requires more steam and that it takes a later cutoff to supply it, is often puzzled to understand how a later cutoff on the low-pressure cylinder of a compound engine makes it take *less* of the load.

The difference is that the high-pressure cylinder has the boiler to draw upon. The longer the admission valve of the high-pressure cylinder stays open the more steam will come into the engine. The low-pressure cylinder, however, has to take what steam the high-pressure cylinder gives it. All of the steam admitted to the high-pressure cylinder must pass through the low whether the cutoff on the latter be late or early. The cutoff on the low-pressure cylinder cannot determine, therefore, how much steam it shall get. It has got to take the same weight of steam that the high-pressure cylinder took. If it takes it at a greater volume it will be at a lower pressure. Therefore if its cutoff is late and it takes a large volume out of the receiver it will take it at a lower initial pressure for itself, making its capacity less, and leave a lower receiver pressure or back pressure for the high-pressure cylinder, making its capacity greater. An attempt to explain this diagrammatically will be found on page 180.

Although Herbert Knox Smith, Commissioner of Corporations, has resigned, we trust that the campaign to retain, lease and develop water-power sites will be as vigorously carried on as before. Mr. Smith has done much in this direction, and we hope his successor will do as well or better.

The Bureau of Standards is able to determine the millionth part of an inch, says *Technical World Magazine*. Now we can approximately estimate the "progress" made by a few people we all know, where heretofore we were doubtful if some of their little movements had any forward significance.

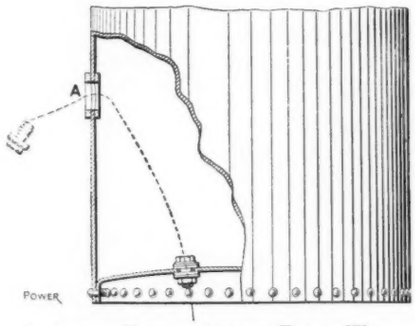
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Novel Leaky Tank Repair

A jet of water about the size of an ordinary sewing needle, shot forth from the bottom of a small tank which an engineer was testing. The usual way of repairing such leaks is to drill and tap a hole for a machine screw. This would not do in this case for the drilling revealed that corrosion had eaten the bottom of the tank at this point to not over $\frac{1}{16}$ in. thick.

It was decided that a patch should go on the inside, something after the style of a manhole plate in a boiler. A ¼-in. stove bolt with a smooth, flat surface on



SHOWING HOW A LEAKY TANK WAS PLUGGED

the under side of its head was fitted with a small washer of thin good quality packing; a smooth fitting iron washer followed next and finally another washer of rubber packing ⅛ in. thick.

A piece of flexible lamp cord was passed up through the leak hole and hooked out through the 1¼-in. hole *A* in the illustration. The wire in the end of the strand was untwisted and bound to the threaded end of the bolt, over which had been slipped the several washers. The bolt and washers were guided through the 1¼-in. hole and the end of the bolt passed through the leak hole as shown. A washer of ⅛-in. rubber packing, a metal washer and a nut were then put on the outside and the leak was effectually stopped by tightening the nut.

T. H. REARDON.

North Adams, Mass.

Shaft Governor Lubrication

The speed-control device on reciprocating engines driving generators, where the machines must carry a fluctuating load, must be so designed as to afford all simplicity, accuracy and good workmanship possible. This is a vital matter to the different engine manufacturers.

Some time ago I bought two second-hand 50-kw. 250-volt direct-current generators directly connected to simple engines equipped with a shaft governor. These engines, as could be plainly seen, had been severely used; the governor pin, holding the eccentric to the arm and counterweights of the governor, and the bushing in the flywheel were so worn that before reinstalling these engines, it was necessary to rebush the bearings to get the eccentric face parallel to the faced part of the flywheel; otherwise the governor would not work properly.

When I removed these old brass bearings I found that the grease-holes did not penetrate through the bushing, making it impossible to get lubrication at the bearing point. I found also that in the governor there is a vital part where lubrication is needed badly, yet the only way to apply it is with the ordinary oil can. When these engines were started they would race past the rated speed, making it necessary to throttle them by hand, unless the load was put on as the normal speed limit was passed. It occurred to me one day to thoroughly oil the bearing end of the spring, where the loop connects to the shift pin in the governor arm. This proved a remedy for the racing.

Obviously the spring tension and the pulling force caused by the rotation of the counterweights in the governor arm at a point off center, act through an arc determined by the point of suspension and considerable friction is caused at this point. This friction is such that it does not let the weights act to throttle the engine at the proper moment.

A close regulation in speed has been obtained ever since, by keeping this bearing point well greased.

ALBERT R. MESA.

New York City.

Power Plant Dangers

Several years ago a water arch on a boiler was cut out of service by removing the steam connection while the water nipple was capped and left in the boiler. Lately it became necessary to rebuild the brickwork of this furnace and this gave an opportunity to remove the water arch. The old nipple was noticed and a wrench was applied to remove it, but the cap dropped off with the slightest touch.

Undoubtedly something serious would have happened if this burnt nipple and cap had blown off while the boiler was under high pressure. This case shows that there are many little dangers lurking in our boiler rooms, and that an eternal vigilance should be exercised to keep all things right. It would be interesting to learn of the many things in need of immediate attention which can only be discovered by a systematic search for them.

F. WEBSTER.

Scranton, Penn.

Cement Enclosed Leaky Pipe Joint

Often, in an emergency, it becomes necessary to make up joints in an unusual manner, due to lack of facilities, or peculiarities of the situation not allowing ordinary treatment.

An unusual experience came to me last year while isolated in the wilds of southern Mexico, where supplies of all kinds were out of immediate reach. We had an "air-return" water-supply system for a sugar factory and distillery, using two large compressors in the factory and four submerged tanks at the river in a pit. The discharge pipe from the river tanks was of 16-in. spiral construction.

A section near the river had to be renewed, and where the pipe reached the river bank was a rise which made an angle in the line of about 40 deg. The pipe was fastened at the joints with flanged stuffing boxes, and on putting in the new section and realigning it, we found that the angle was too great to allow using the stuffing-box joint at the angle. The condition was aggravated by the ragged condition of the pipe end on the old section.

Cement had served so well in so many emergencies, that I concluded to build a cement block around the joint, so I had my "albanils" (as we call the Mexican brick masons) build a brick and cement wall around the joint, thinking it would at least serve until I could devise something better, or get a special construction of joint.

We built a block of ordinary red brick and cement around the joint for a distance of 4 ft. and with 9-in. minimum thickness at the four curves of the pipe. This joint was allowed to dry for about two weeks, much longer, perhaps, than was necessary, before we started the pumping. At the starting, and never since, has this joint leaked a drop of water, and it bids fair to equal, if not outlast, the tubing.

A considerable pulsation in the operation of the submerged tanks at time of filling caused vibration in the piping, and, in addition, the joint was exposed to expansion from a tropical sun.

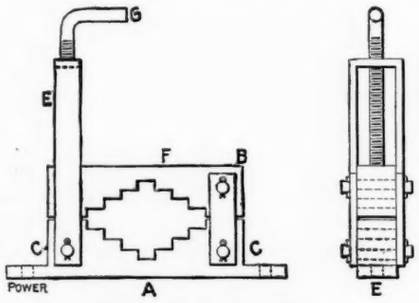
The strength of the joint was not questioned, but it was doubtful whether the brickwork would adhere to the pipe close enough for a water joint, with the vibration, exposure and a distance of 800 ft. and a head of 110 ft. The whole thing was a success and I am more friendly than ever toward cement.

J. O. FRAZIER.

New Orleans, La.

Simple Home-Made Pipe Vise

The illustration shows a pipe vise which will hold pipe from ¾ in. up to 1¼ in., and which can be carried in an inside pocket of a coat. It weighs no



HOME-MADE PIPE VISE

more than a 14-in. pipe wrench. This is the design of a vise actually in use.

At *A* is shown the vise assembled and ready for use. The cotter pins *BC* should be used to secure the cross pins on which hinge the yoke *E* and the upper jaw *F*. By making another hole nearer the right side of *F*, 1½-in. pipe may be held in the vise. The width of the vise should be sufficient to withstand the strain put upon it.

JOHN STRONG.

London Junction, Ont., Canada.

Improvised Planimeters

Although the use of a jack-knife as a planimeter is old, some may not know that quite accurate results can be so obtained.

To find the area of a diagram, the approximate center of gravity is first marked and two lines are drawn at right angles through this point, as at *A*, Fig. 1. The knife should be opened as shown and the point of the small blade placed at *A*, and the large blade on the line which determines the point *A*. Then, with the knife held vertical, the outline is traced with the point of the small blade by moving it around from *A* to *B* in the direction *B, C, D, E, F, B*, and back to *A*, as shown by the full line arrow, Fig. 2. The large blade will move as shown by the curves *a, c, e, x*, Fig. 2, and will stop at *x* when the point of the small blade stops at *A*. The small blade is again placed at *A* and the large blade at *a*. Now, tracing the outline as shown by the dotted arrows, Fig. 2, in the direction *A, D, C, B, F, E, D*, and back to *A*, the large blade will move as shown by the dotted curve *a, c' f*, Fig. 2, and stop at *y* when the small-blade point stops at *A*. The distance between *x* and *y* is called the altitude, and one-half of it, multipled by the length of the instrument, as shown, gives the area of the figure.

A hatchet planimeter can be made by bending a piece of wire into the shape

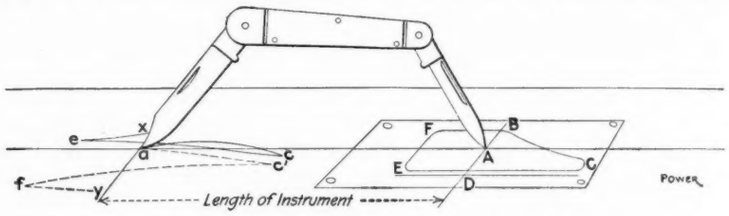


FIG. 1. SHOWING HOW KNIFE PLANIMETER IS USED

shown in Fig. 3. One end of the wire is flattened and filed to a sharp edge and the other end to a sharp point. To give accurate results the edge should be in line with the point, which can be tested by drawing a straight line and placing both point and blade on the line. When the point is moved along the line, if the blade continues to follow the line, the instrument is correct.

In using the hatchet planimeter, the motion of the blade should not be controlled by the operator, but should depend only on the movement of the point.

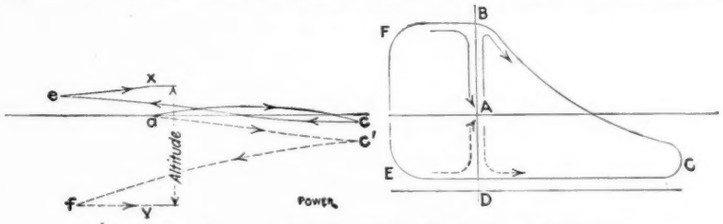


FIG. 2. CURVES MADE WITH KNIFE PLANIMETER

This is easily done by holding the instrument with the thumb and second finger at the bend above the point and pressing down with the first finger about an inch from the bend.

By tracing the diagram in both directions, any error in choosing its center of gravity, or in the alignment of the instrument, is compensated.

FIG. 3. HATCHET PLANIMETER

When the greatest dimension of the diagram does not exceed two-thirds of the length of the instrument, the result will generally be accurate to within 2 per cent., if the work has been carefully done. The planimeter should be held as nearly vertical as possible and the blade should be kept sharp.

The accuracy of the instrument can be checked by using it to measure a circle or other figure of known area.

C. A. GILSON.

East Lansing, Mich.

CO_2 Recorder Salesman's Mistake

Recently a salesman 'phoned me requesting permission to take readings with his CO_2 recording apparatus as he had not take any from a down-draft furnace such as ours and would be pleased to note results. We permitted him as we were anxious to know the percentage of CO_2 we were getting. He talked of CO_2 and conditions of furnaces in other plants which interested me in his recorder.

We have nine boilers of about 2000 hp. and tried a 300-hp. boiler, but the percentage of CO_2 was very low, owing to some baffle bricks being broken over the tubes. It was suggested that repairs be made, after which the taking of readings could be continued. This was done but the new brick did not fit well, so our readings were still very low. Then we thought to cover the top of the brick with fireclay and put some asbestos under them, as this would stop all the air leaks at this point.

We were ready for the third readings, but they have not yet been taken. Instead I was called in the office by the manager who informed me that a letter from the firm that sold us the boiler we tested for CO_2 stated that from information received they believed our firemen were "green" men and were breaking the firebrick over the tubes, causing low furnace efficiency. This was untrue, as these bricks could not be broken with the fire bars and the men were not "green" but of good character and ability.

How did the boiler firm know these bricks were broken? Their representatives were not there to see them, so we concluded and later proved that our

friend the CO_2 man peddled the misinformation.

We had faith in this man and did him a favor; furthermore, we became so interested in his recorder that we intended purchasing one. But on account of his indiscretion he could never sell recorders or anything else to us now. A salesman should remember that it is the engineer after all that has the "say so" about buying material or apparatus and he should aim to treat him right.

JACOB SWARTZ.

Philadelphia, Penn.

Overflow Oil from Turbine Step Bearings

Engineers in charge of vertical Curtis turbines know from experience the disagreeable mess resulting from a "slush" of oil out through the bottom seal pipe. These so-called slushes are usually the result of an oversupply of lubricant to the step bearing. Referring to Fig. 1, the oil enters at *A*, finds its way through the step bearing to the chamber *B*, and works up along the shaft and out through the oil drain, as indicated by the arrows at the left. An oversupply of oil is likely to find its way into the water drain, as indicated by the arrows at the right.

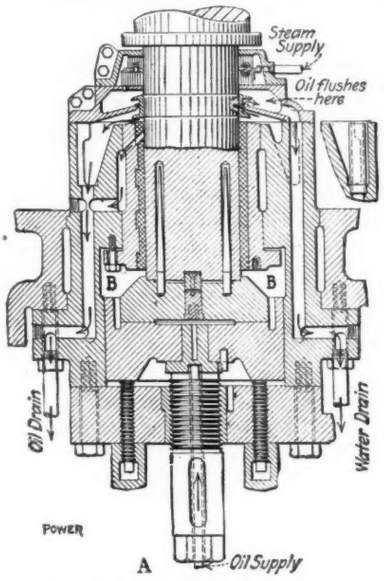


FIG. 1. TURBINE STEP BEARING

Were the return pipe large enough to take care of such an oversupply, no slush would result; but the pump speed cannot always be adjusted finely enough under all conditions to avoid these occurrences.

A vertical Curtis turbine is to be started. It is cold and the oil is cold also. After the large oil cup at the top has been set to feeding, the oiling system turned on, the governor well oiled, the swivel also, and so on, with the governor links down to the valve-gear cams, the hydraulic valve control in action, etc., we are ready to start the oil pump. Crack the steam throttle, start the pump moving slowly and observe the oil pressure rising on the gage. If 200 lb. is usually carried, some 125 lb. may now register, with the throttle just cracked.

Give it more steam, until you see 200 lb. oil pressure. Then slow the pump down gradually slightly and 200 lb. may still be indicated on the dial. Slow it down again, but be careful not to overdo this, for you must be certain that the gage registers no less than the proper pressure, or the step-bearing surfaces may be injured by rubbing.

The main throttle of the turbine may now be cracked open. You will see that the turbine is turning by glancing at the governor at the top. By being allowed to run slowly it gradually heats up equally in all its steam chambers and parts. It is advisable to let it run thus for not less than 10 min., after which it is ready to be set to work.

To return to our oil slush, let us assume that the machine is running at full speed with only half the usual load. The oil, being comparatively cold, does not return as readily to the filter as later when heated. It may be necessary to speed up, or even to slow down, the pump slightly, for right here is where keen judgment must be exercised in adjusting the pump speed to maintain the 200 lb. of step-bearing pressure, and simultaneously avoid an oversupply.

The overflowing of oil takes place at the steam seal of the gland, as shown in Fig. 1, and continues for several minutes, during which the attendant is kept dancing between the Scylla of an insufficient oil pressure and the Charybdis of a slush. It gradually diminishes and finally ceases as the fluid warms up and takes its regular course through the return pipe to the cooler and filter.

On some turbines the seal is turned upward, instead of downward, and the overflowing oil runs into the vacuum chamber and continues on into the condenser, instead of out the seal pipe; where adequate means are not provided to trap the oil, if the condensation water is used for boiler feed, the oil eventually finds its way into the boilers.

I take care of the escaping oil by means of the arrangement shown in Fig. 2. The leakage drips into the can, and the oil and water separate by gravity. The oil is drawn off by the cock *C*, and returned to the system; the water by the cock *D*, into a drain which leads to the brook. If it should be neglected until the level rises to *A*, the contents will siphon over to the drain, the water going over first.

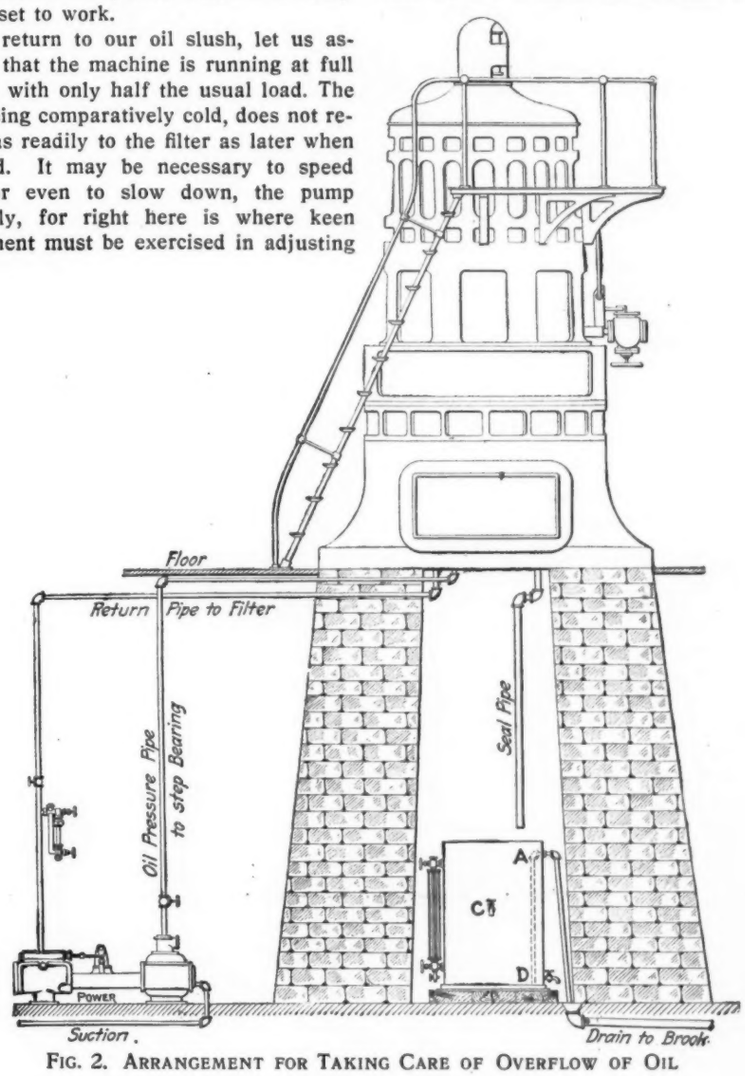


FIG. 2. ARRANGEMENT FOR TAKING CARE OF OVERFLOW OF OIL

LUKE MARIER.

Fall River, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Efficiency of Joints in Boiler Shells

H. L. Strong's article under this title in the May 14 issue, is an excellent treatment of the subject which is the kind POWER readers appreciate. I cannot understand, however, why Mr. Strong did not give the analysis of well designed joints instead of poor ones.

The joints mentioned by him have efficiencies of only 42.9 per cent. for the single-riveted lap joint, 64 per cent. for the double-riveted lap joint, 75.9 per cent. for the triple-riveted butt-strap joint and 84.5 per cent. for the quadruple-riveted butt-strap joint. With well designed joints he could have obtained 60, 70, 86 and 94 per cent., respectively, for the above joints.

When he figured the bursting pressure of shells having these joints he could have given his readers accurate and up-to-date information, and still show the method of calculating the efficiencies of the different joints.

F. P. SOMERS.

Cleveland, Ohio.

F. P. Somers' commendation of my article is gratifying, coming as it does from one who is familiar with the subject. There is a little error in Mr. Somers' letter. The efficiencies of the joints as calculated were 42.9 per cent. for single-riveted lap seam, 64.3 per cent. for double-riveted lap seam, 75.9 per cent. for double-riveted butt-strap joint, 84.5 per cent. for triple-riveted butt-strap joint and 93.75 per cent. for quadruple-riveted butt-strap joint. It will be seen that the last joint is within ¼ of 1 per cent. of the value which he suggests as good practice for that type of joint. I also stated that this joint was of standard design.

I gave the rules, demonstrated how and why they were used, and gave the American Boiler Manufacturers rules for designing joints. I then used haphazard designs, first to impress upon the minds of interested readers the whys, wherefores and results of improper designs, and, second, so that those familiar with the subject could not say that it was "copied from a book." Not long ago I heard an engineer say: "Why go to so much trouble in figuring joints; I've got a rule that beats that because it gives the same result and is shorter."

The rule he referred to, and advocated using on all occasions, was the short rule which I mentioned. I have supplied the necessary fundamentals for calculating the efficiency of joints, and those interested enough to read the article carefully should find it of value.

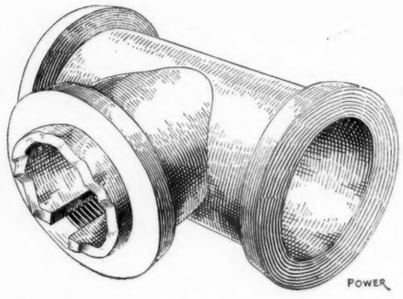
H. L. STRONG.

Portland, Maine.

Removing Broken Pipe Ends

A. T. Kasley gives a good suggestion on this subject in the Apr. 30 issue, and reminds me of the following way of doing this work.

I have found a cape chisel, machinist's hammer and a common hacksaw blade all



BROKEN PIPE-END SPLIT FOR REMOVAL FROM FITTING

that is necessary. Make two cuts ¾ in. apart in the pipe end with the hacksaw, sawing nearly through the pipe. With the hammer and chisel remove the ¾-in. strip, as shown in the illustration. The remaining ends can be curled into the center of the fitting and removed very easily.

CARL A. EVERETT.

Mescalero, N. M.

Careless Pipe Work

W. H. Wakeman's letter in the July 9 issue, under this heading, reminds me of a 150-hp. boiler installed in our plant in 1900. The feed-water piping was of extra-heavy pipe, and the only good joints were the flanged ones. The pipe was screwed up even with the face of the flange, but all the other joints were screwed in the fittings with only two and three threads holding. The joints in the water column were put together in the same careless manner. This work was done by a supposedly good firm considered to employ reliable men.

We discovered these defects about two years ago when the boiler was reset and all the piping renewed. The old piping was used steadiiy for 10 years, only being out of service while the boiler was shut down for cleaning. If any of these joints had failed the fireman would undoubtedly have been fatally scalded. We heat our feed water to 212 deg. F.; the pressure carried is 100 lb.

HARRY E. KOFFEL.

Doylestown, Penn.

A Contemptible Fraud

The editorial on the above subject in the June 11 issue is worthy of comment. In nearly every large power plant just such tricks occasion great annoyance, but to catch the guilty shirk is difficult.

As long as there is sufficient steam to keep the plant running, no attention is paid by the man in charge of the boiler room to who makes the steam, and only too frequently some good fireman will quit work without any apparent reason, knowing only too well the futility of preferring a charge of neglect against his co-worker. Generally a complainant is soon marked as a kicker and incurs the enmity of his fellows as well as the chief; for this reason most men prefer to leave rather than get into trouble with others.

I have seen this trick played with the blower valves and the feed valves and with all kinds of bad fires, and it is only detected when the good fireman lets the steam pressure drop to a point noticeable enough to attract the chief's attention. Even then the cause may not be found until this shortage of steam has become very annoying. Then the chief will scout around the boiler room when his presence is not known. But the shirk is usually clever enough to avoid immediate detection. By observing the amount of water evaporating in each boiler, the perfidious workman is soon discovered.

In large plants it is common for a fireman to leave an exceedingly poor fire when making the last shake, prior to being relieved. This compels his relief to start work at a great disadvantage, especially if the fuel is poor and the load heavy. It is the engineer's duty to eliminate this practice in his plant, even though every guilty fireman has to be discharged.

R. A. CULTRA

Cambridge, Mass.

Clearance by the Logarithmic Diagram

In a recent issue of POWER you had an article on the use of the logarithmic diagram for determining the conditions in a steam engine as shown by the indicator card, and in this article you asked for reports on results obtained by this method. I have used this method on two separate engines, one a single-cylinder simple engine and the other a tandem-compound engine. I am sending you with this letter blueprints of the curves obtained from each engine.

The curves from the simple engine, Fig. 1, seem to show that unless the engine has a tight piston the clearance cannot be estimated from these diagrams. The clearance of this engine is not known and the engine is known to have some leakage by the piston. This diagram was plotted assuming clearances from 6 to 26 per cent. and an attempt made to find out the true clearance from the shape of the compression and expansion lines. The compression lines seem to show the clearance as about 18 to 26 per cent. and the expansion lines show it from 6 to 8 per cent., that is, the lines are straight in these regions. As the compression and expansion lines are not straight for the same per cent. of clearance it seems to me that this shows a leakage and also, if there is such leakage, that the logarithmic diagram cannot be used to estimate the clearance. I am also sending the indicator card from which this is plotted.

The diagram, Fig. 2, plotted from the high-pressure crank-end card from a compound engine which we know is tight, seems to show a clearance of 1½ per cent. This seems to strengthen the statement in the previous paragraph that the cylinder must be tight, as there was no trouble in estimating the clearance in this engine. Due to the small clearance the diagram could not all be put on the paper at hand. I have also inclosed the indicator card from which this plot was made.

C. W. WILSON.

New Britain, Conn.

The new analysis of the indicator diagram given by J. Paul Clayton is bound to mark an epoch in power-plant work and engineers will do well to preserve for ready reference the very able analysis of his paper which appeared in POWER, June 18.

For the application of the new method it is essential that the clearance of the engine be accurately known and the proper determination of this constant of the engine requires considerable time and skill at best, while under engine-room conditions it is sometimes well nigh impossible.

Manifestly the best time to measure clearance is when the engine is on the testing floor of the factory. Here laboratory conditions prevail to a certain extent and men are available who are skilled in such work. Hereafter no engine, steam or gas, should be allowed to leave the factory without an accurate clearance determination, the result to be recorded at the factory and certified to the buyer, or better yet stamped on the name plate. This will only come about through the insistance of each buyer that he be furnished with this information, information which has now become essential in the uptodate management of a power plant.

It is also necessary for the man buying a gas engine to insist that his engine be properly equipped for indicator attachment, since most gas engines of small and medium size are made with no provision for attaching either indicator or reducing motion. Fitting a steam engine for an indicator is quite simple, but due to the water jacket and the absence of a crosshead, properly equipping a trunk-piston gas engine is frequently a serious problem.

The engineer *may* be able to measure the clearance and he *may* be able to equip for the indicator, but the engine builder is better fitted to do these things than any engineer and will do them if the buyer insists.

G. W. MUNRO.

LaFayette, Ind.

During the past year, Stevens Institute of Technology has received $56,000 in gifts, as announced by President Humphreys at the recent alumni association meeting.

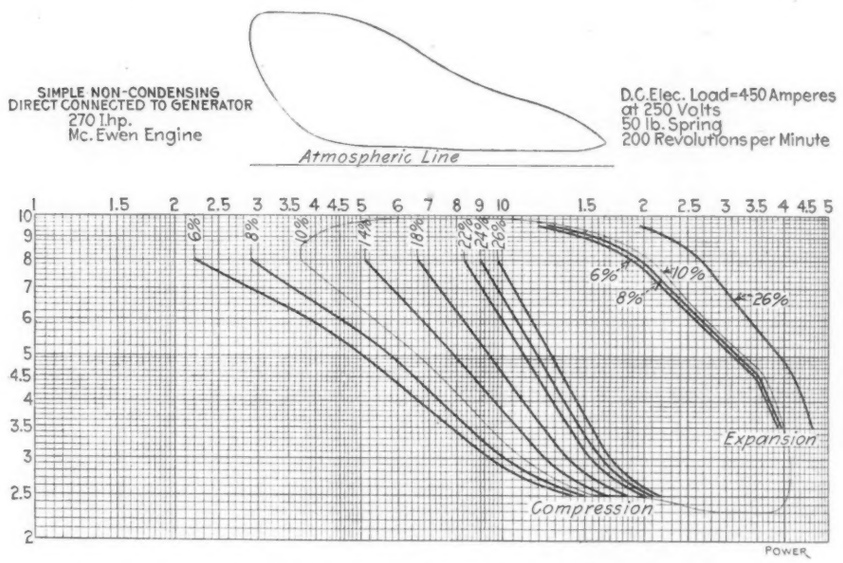


FIG. 1. SIMPLE ENGINE DIAGRAM CURVES PLOTTED LOGARITHMICALLY

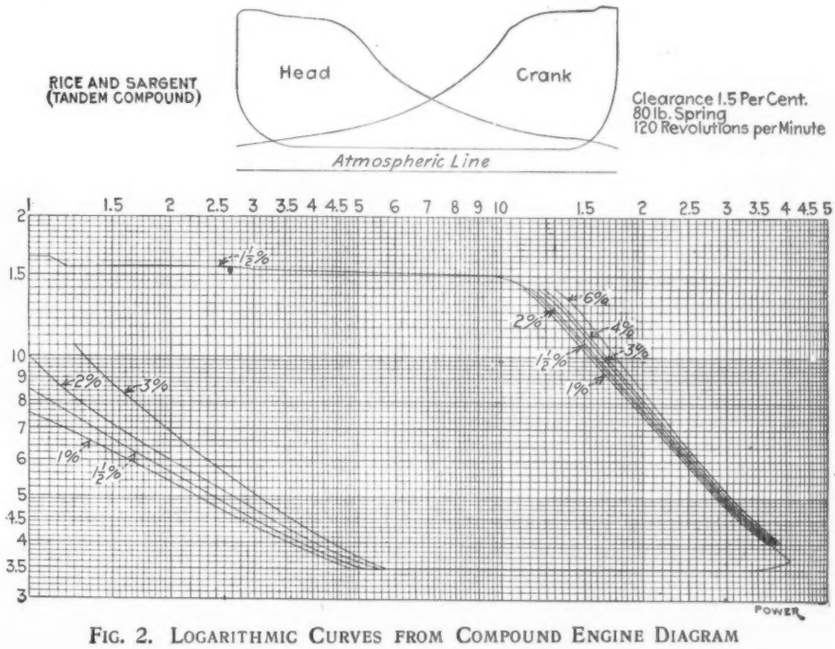


FIG. 2. LOGARITHMIC CURVES FROM COMPOUND ENGINE DIAGRAM

New Smoke Inspection Methods at Chicago

Heretofore a chimney was held to be a smoke nuisance by the Chicago smoke-inspection authorities when it emitted smoke of No. 3 density, according to the Ringelmann chart, for 7 min. during one hour, as based on the original ordinance. With this standard the owners of a chimney which emitted but a very small total quantity of smoke might be liable to punishment, whereas with a chimney which continuously emitted smoke of a density less than No. 3, the owners would be safe from legal prosecution, although the total quantity emitted might be many times as great.

In future, the total smoke emitted will be taken into consideration. Observations will be made on a given stack every 15 sec. throughout the entire day and the total "smoke units" will be recorded, from which the average smoke density for the entire period will be calculated.

A "smoke unit" is the equivalent of No. 1 smoke (Ringelmann scale) emitted for one minute. No. 1 smoke has a density of 20 per cent.; No. 2, 40; No. 3, 60; No. 4, 80, and No. 5 100 per cent. Thus, if a stack emits No. 3 smoke for 6 min., 18 smoke units are charged against it. If this smoke was emitted during one hour's observation, then

$$\frac{3 \times 6 \times 20}{60} = 6 \text{ per cent.}$$

is the average density of smoke emitted during the period of observation.

If observations on a given stack show that the density averages more than 2 per cent., although the owner may not be legally liable, an appeal is made to his personal and civic pride by a representative of the smoke-inspection department. For example, if a certain hotel stack emits smoke of more than 2 per cent. average density, the smoke department finds a plant record of similar design and equipment, preferably a hotel plant, which shows a record well below the 2 per cent. mark. This plant is then pointed out to the owner or manager having the objectionable chimney and he is asked if he cannot do equally well when he has practically the same equipment, etc.

It has been found that this method of procedure often produces quicker and better results than a threat to go to law.

Otto Kretschmer, of the Charlottenburg Technical High School, in his plans for an unsinkable ship, embodies the principle of a hull within a hull, says the *Scientific American*. The inner body, wholly independent of the outer, contains the engines and boilers, and is walled in with steel plating through which are no doors communicating with the space between the inner and outer structures.

Indicating Hot Well

This attachment is secured beneath the condenser, as shown in Fig. 2. The opening in the bottom of the condenser is built so that the condensate drains into the left chamber of the hot well, and communication from this chamber to the hotwell pump suction is secured through an orifice in the dividing wall.

The velocity of discharge through an orifice of given diameter, varies directly as the square root of the head, and the quantity of water discharged is equal to the product of this velocity, the area of the orifice and the coefficient of contraction. With a properly designed orifice this coefficient remains almost exactly constant for widely different values of the head upon the orifice, and therefore the quantity of discharge is obtained with a high degree of accuracy by a carefully calibrated indicating gage-glass, Fig. 1, reading the head.

FIG. 1. THE GAGE

The orifice is formed in a brass plate inserted in the partition wall. It is polished and finished to insure accuracy of flow. Special fittings are used to attach the indicating gage to the shell of the hotwell. Ball check valves are provided in each fitting so that should the gage-glass break the inflow of air will be prevented, and the gage-glass can be replaced at leisure. A gage-glass is also provided to show the height of the water in the hotwell suction compartment, where the water must not be allowed to submerge the orifice. The scale attached to the indicating gage reads directly in pounds of steam per hour. Each orifice is made independently, carefully calibrated, and a special scale, etched upon steel, furnished for it. Over the whole range of readings the accuracy is said to be within 2 per cent. and for readings from 75 per cent. to 125 per cent. load, the accuracy is within 1 per cent.

The device is manufactured by the Wheeler Condenser & Engineering Co., Carteret, N. J.

Stumpf Engine of 2400 H.P.

There has been in use since February, 1912, at the Rombacher Iron Works, Germany, a 2400-hp. Stumpf mid-cylinder exhaust engine which is the most powerful unit of this type ever built. The cylinder diameter is 1080 mm. (43 in.), and the stroke 1300 mm. (52 in.). The engine runs at 120 r.p.m., a notably high speed for this type, giving a piston speed of 17.2 ft. per second. The regulation is exceptionally exact. No appreciable drop in speed can be detected even with the highest loads, nor can any overspeeding be discovered when the load is suddenly removed. The engine is used to drive a 600-mm. (24-in.) rolling-mill. It is coupled directly to the rolling-mill shaft and has a flywheel weighing 71 tons.

A new aërial ropeway of Potosi Department, Bolivia, reaches an altitude of 17,045 ft. It is somewhat more than two miles long and carries ore from tin mines to mills 2700 ft. lower down. The ore buckets, working by gravity, transport 6 to 8 tons an hour.

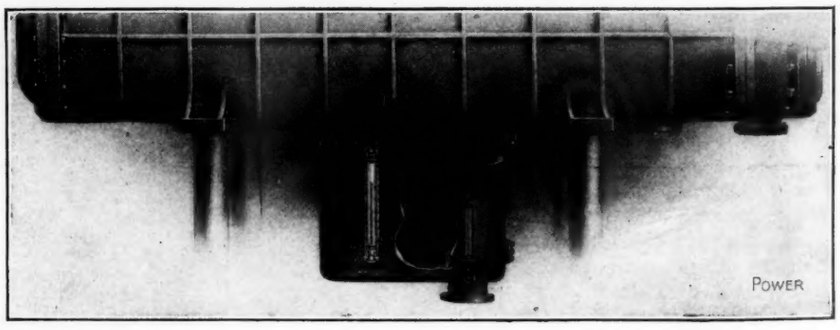


FIG. 2. WHEELER INDICATING HOT WELL

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Pumping Connected Wells

Can as much water be raised from three 2-in. pipe wells arranged in a straight line and spaced 25 ft. apart when all are connected into one suction pipe with a pump at one end, as when each well has a separate suction pump?

A. J. V.

No. In consequence of differences in frictional resistance to the flow in the well pipes and their connections to a single-suction pipe, the flow will not be the same from each well, and the most active discharge will retard the others by choking off their flow to the pump, without a proportionate increase of its own discharge.

Paint on Interior of Boilers

Would any benefit be derived from painting the interior surface of boilers?

L. P.

Yes. The interior surfaces of boilers which have been painted before any corrosion has taken place, have been known to remain free from rusting for several years, while adjacent surfaces on the same plates, left uncoated, have been found to rust and pit rapidly.

Very Small Water Power

How much power could be realized from a stream of water 18 in. wide, 6 in. deep and flowing with a velocity of 21 ft. per minute and a fall of 4 ft.

J. H.

The discharge would be $18/12 \times 6/12 \times 21 = 15.75$ cu.ft. per minute, which would be $15.75 \times 62\frac{1}{2} = 984.375$ lb., and with 4-ft. fall the discharge would develop $984.375 \times 4 = 3937.5$ ft.-lb. per minute $\frac{3937.5}{33{,}000} = 0.119$ hp. in the water. The amount of power realized would depend on the efficiency of the water wheel. An overshot wheel could be constructed with curved buckets giving an efficiency of 75 per cent. so that there could be realized about 0.09 horsepower.

Strength of Staybolts

The wrought-iron stay-bolts of a locomotive type of boiler are 1 in. in diameter and spaced 5 in. on centers each way. How much boiler pressure per square inch should they resist?

P. C.

Assuming that the stay-bolts are screw cut, with 12 V-threads per inch, they would have a diameter at the bottom of the thread of 0.8557 in. and cross-sectional area of 0.575 sq.in.

Placing the allowable load at 6500 lb. per sq.in. would make $6500 \times 0.575 = 3737.5$ lb. allowable load. Spaced 5x5 in., each stay-bolt would sustain 25 sq.in. and the allowable boiler pressure would be $\frac{3737.5}{25} = 149.5$ lb. per sq.in.

Noisy Exhaust Valves

What is the cause of the slamming noise of the exhaust valves of a Corliss engine when driving a light load and how can it be prevented?

J. B.

When the initial pressure is so high and cutoff so short that expansion takes place below the pressure into which the engine exhausts, the sudden reversal of pressure on the exhaust valve forces it from its seat. Although there may be very little play for movement of the valve, it is arrested and returned to its seat like the pounding of a check valve. On account of the large area of the exhaust port, only a very small change of pressure is sufficient to produce this annoyance. It can be prevented by carrying lower initial pressure and later cutoff, or for the high-pressure cylinder of a condensing engine, by carrying a lower receiver pressure. Where the load of a noncondensing engine is variable and it is impracticable to throttle or carry lower pressure when driving light loads, the noise can usually be stopped by joining together the indicator connections of the opposite ends of the cylinder with a stop valve in the connecting pipe nearly closed, or if not objectionable, by leaving separate indicator connections slightly open to the atmosphere.

Coal Required for Increase of Back Pressure

If the diagram from a noncondensing engine with 5 per cent. clearance shows an initial pressure of 115 lb. abs. and the cutoff is at one-half stroke, how much must the initial pressure be increased to develop the same power with the same point of cutoff, if the average total back pressure is increased 5 lb. per sq.in. for exhaust-steam heating, and the exhaust valves are set for the same increase of average back pressure from compression? How much more steam and how much more coal will be required, the feed water in each case being at 200 deg. F.?

M. C. G.

For any percentage of clearance and any point of cutoff the mean effective pressure per pound absolute may be found by the formula

$$P_m = (1 + log_e R)\,(f + c) - c$$

in which

P_m = Mean forward pressure per pound initial;

R = Ratio of expansion $= \frac{1 + c}{f + c}$;

f = Fraction of stroke completed at cutoff;

c = Percentage of clearance;

where

$f = 0.5$;

$c = 0.05$;

$$R = \frac{1.05}{0.5 + 0.05} = 1.90909$$

The hyperbolic logarithm (log_e) of $1.90909 = 0.6466$.

Substituting these values in the formula:

$(1 + 0.6466) \times (0.5 + 0.05) - 0.05 = (1.6466 \times 0.55) - 0.05 = 0.8556$

Therefore to reëstablish the same total mean effective pressure after increasing the average back pressure 5 lb., the initial pressure of 115 lb. abs. would have to be raised $5 \div 0.8556$ lb. $= 5.84$ lb., i.e., it would have to be increased to practically 121 lb. The density of steam at 115 lb. pressure abs. being 0.2577 lb. per cu.ft., while the density at 121 lb. pressure abs. is 0.2705 lb. per cu.ft., then as the point of cutoff would be the same in both cases, the same number of cubic feet of steam would be used, but the weight, $0.2705 - 0.2577 = 0.0128$ lb. more per cubic foot would be required; i.e., the percentage $(0.0128 \times 100) \div 0.2577 = 4.967$ per cent. more steam. As one pound of steam at 115 lb. abs. raised from feed water at 200 deg. F. requires $(1188.8 - (200 - 32) = 1020.8$ B.t.u., and for 121 lb. abs. would require $(1189.7 - (200 - 32) = 1021.7$ B.t.u., then each pound raised to the higher pressure would require $(1021.7 - 1020.8) \times 100 \div 1020.8 = 0.088$ of 1 per cent. more heat. The 4.967 per cent. more steam would therefore require $104.967 \times 100.088 - 100 = 5.059$ or about 5 per cent. more heat and consequently that much more coal.

Study Questions

This Week's Questions
Last Week's Answers

(61) What will be the temperature rise, neglecting radiation, of 1 cu.ft. of water containing a coil of 5 ohms resistance through which a current of 22 amp. flows for 15 min.?

(62) The heat required to evaporate 1 lb. of water from and at 212 deg. F. is 970.4 B.t.u. How much water will be evaporated by 1 ton (2000 lb.) of coal of a heat value of 14,000 B.t.u. per lb.?

(63) What horsepower is transmitted by a shaft carrying a 14-in. pulley running at 180 r.p.m. when the tension in the tight side of the belt is 600 lb. and in the loose side 300 lb.?

(64) If a flywheel weighs 7000 lb. and has a mean radius of 5 ft., how much energy is stored in it when revolving at 70 r.p.m.?

(65) Suppose, after measuring a number of indicator diagrams, it is discovered that the planimeter was set for a diagram length of 3 in., when the actual length of the diagrams was 3½ in. The average horsepower as found was 435 i.hp. What should it have been?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

(56) Let x = height of stack.

Then $x - 62$ = distance of man from top and $100 - (x - 62)$ = distance from top to ring = $162 - x$.

By the relations of the sides of a right triangle

$$(162 - x)^2 = 54^2 + x^2$$
$$26{,}244 - 324x + x^2 = x^2 + 2916$$
$$324x = 23{,}328$$
$$x = 72 \text{ ft.}$$

(57) The formula for the Wheatstone bridge measurement of resistance is

$$x = \frac{r_1}{r_2} R$$

From the problem then

$$x = \frac{10}{100} \times 343 = 34.3 \text{ ohms}$$

(58) The heat consumed would be merely the equivalent of the work done or

$$\frac{2000 \text{ lb.} \times 500 \text{ ft}}{778 \text{ ft.-lb.}} = 1285.35 \text{ B.t.u.}$$

(59) The uniform load may be considered as acting at the center of gravity, therefore, having an arm of 7½ ft. about one support. The concentrated loads about the same support have arms of 5 and 10 ft. respectively. From the summation of moments then

5000 lb. × 7½ ft. = 37,500
3000 lb. × 5 ft. = 15,000
4000 lb. × 10 ft. = 40,000
92,500

is opposed to the reaction of the other support acting about an arm of 15 ft. Therefore

$$\frac{92{,}500}{15} = 6166.66 \text{ lb.}$$

is the weight on one support. The weight on the other support might be found similarly by taking moments about the support just figured, but it is quicker to subtract the latter from the total load as the sum of the loads must equal the sum of the support reactions. Therefore

$$5000 + 3000 + 4000 - 6166.66 = 5833.33$$

is the load on the other support.

(60) The conditions are the reverse of a free fall, the cannon ball being retarded by gravity. Therefore the formula applies

$$s = \frac{v^2}{2g}$$

where

s = Height;
v = Velocity;
g = Acceleration of gravity = 32.2.

Substituting

$$s = \frac{1000^2}{64.4} = 15{,}527 \text{ ft.}$$

Big Power Plant at Providence

One of the features of the electrification of the New York, New Haven & Hartford R.R. between Boston and Providence will be the erection of a big power plant at that city. The railroad announced recently that work on the electrification of that section of the system would be begun next fall and that it will mean an outlay of between $6,500,000 and $7,000,000.

It is proposed to operate this line by a single generating plant to be established at Providence, to supply the current for both southbound and northbound trains. The entire electrification will be overhead trolley and single-phase alternating current, corresponding to the type employed on the New York-to-Stamford end.

Toxaway Water Power Sold

W. E. Moore, according to the Asheville, N. C., *Citizen,* has purchased the Toxaway water power for $400,000. Much attention has been attracted to the report on water power and forests recently issued by a committee of the Western North Carolina Association. The fact that there is 20,000 hp. ready for use simply by laying conduits or pipes, as expressed by the engineer, means that there will be rapid development of the water power from Toxaway.

Education for Self Supporting Boys

Chattanooga Institute of Technology has arranged with manufacturers of that city whereby engineering students are enabled to earn all expenses while attending school. The time required for completing the course is 60 months.

The student works in some industrial establishment for one week and attends the institute the next week, thus devoting half his time to theory and the other to practice while he is obtaining wages enough to pay all of his expenses. The president of the institute is Prof. H. E. Bierly, Chattanooga, Tenn.

Three Cents per Kilowatt Hour

In July last, a schedule of rates to be charged by the Winnipeg municipal plant was prepared, the same being 25 per cent. under the rates charged by the private company, which rates had been set at 10c. per kw.-hr. with a 10 per cent. discount at the time of initiation of service of its own hydro-electric plant in 1906.

Since that date, the municipal authorities have taken a step which is perhaps hard for an engineer to consider warranted—that of reducing the rate for residential lighting to the very low figure of 3c. per kw.-hr. This rate was instituted in December, 1911, and was immediately met by the private company.

The chief argument which prevailed in the making of this decision was that of endeavoring to compel the citizens to become customers and supporters of the municipal institution, the City Council assuming that earnings on similar low rates would make the plant self-supporting when the present equipment should be loaded to full capacity.—*Engineering News.*

Flood Shuts Down Power Service

Flood damage, according to a press report, caused a $200,000 loss at Wausau, Wis., on July 24, by the breaking of two dams on the Wisconsin River. Three bridges have been washed out and a fourth partly destroyed. All the electric power plants and the street-car service were put out of commission.

Alligator in Wrong Tank

At the power plant of the Struthers-Wells Machine Co., Warren, Penn., on July 18, one of the big gas engines stopped and 400 men were afforded a two-hour rest. The experts investigated the cause of the shutdown, and in a short time discovered that an alligator had been pumped into the water tank and was stuck fast in the engine.

Minnesota N. A. S. E. Convention

On June 17, the third annual Minnesota state convention of the National Association of Stationary Engineers, in session July 17 to 20, convened in Philharmonic Hall, Winona, Minn., amid a representative gathering of delegates, visitors and ladies.

James F. McCoy, of Winona, chairman of the convention committee, made the introductory address, followed by the invocation of the Rev. Frank Doran, pastor of the First Methodist Church of Winona, Mayor J. R. Schroth's address of welcome was responded to by Jesse M. Williams, Minneapolis No. 2.

Hon. James A. Tawney, former chairman of the appropriations committee of the House of Representatives, spoke on the principles of universal peace. Mr. Tawney was an engineer before he studied law and entered public life, and his address was roundly applauded. National-Secretary Raven reviewed the work of the National Association of Stationary Engineers and the steady progress it has made.

An informal reception was tendered the visitors in the evening and an inspection was made of the 40 booths of the Central States Exhibitors' Association, arranged on both sides and in the rear of the convention hall.

On Thursday, with State-President Frank J. Strieff presiding, Charles W. Naylor, of Chicago, reviewed the history of the association and talked interestingly on the work under way in Illinois. He praised Minnesota for having acquired a state license law and spoke of the efforts being made for a license law in Illinois. He predicted that public confidence in the association would continue. In his annual address, President Strieff advocated several changes throughout the state. The treasurer's report showed that the total yearly receipts were $515.35; the expenditures $326.60, leaving a balance of $188.75.

The afternoon session developed several interesting discussions and a brief talk by National-Secretary Raven. Messages of regard were received from President E. H. Kearney and Mayor Herbert Keller, of St. Paul. The session adjourned at four o'clock.

During the session the Central States Exhibitors' Association had prepared a "kangaroo court" in the convention hall, with a judge, policemen and a prosecuting attorney. "Judge" Raven fined the prisoners from 50 cents to $5 each. The delegates entered into the fun like schoolboys and when the day was over nearly $100 had been secured for the ladies' auxiliary. The delegates' ladies took an automobile ride during the day and the evening was spent with the exhibitors in the hall.

On Friday morning the routine business was transacted. At the afternoon session, Gen. James H. Harris, of Chicago, lectured on "The Relationship of the Engineer to his Employer." W. A. Converse, of Chicago, followed with an address on "Some Boiler Troubles Attributable to Feed Water." An address was also made by W. L. Osborne, secretary of the Central States Exhibitors' Association, for which he was tendered a vote of thanks.

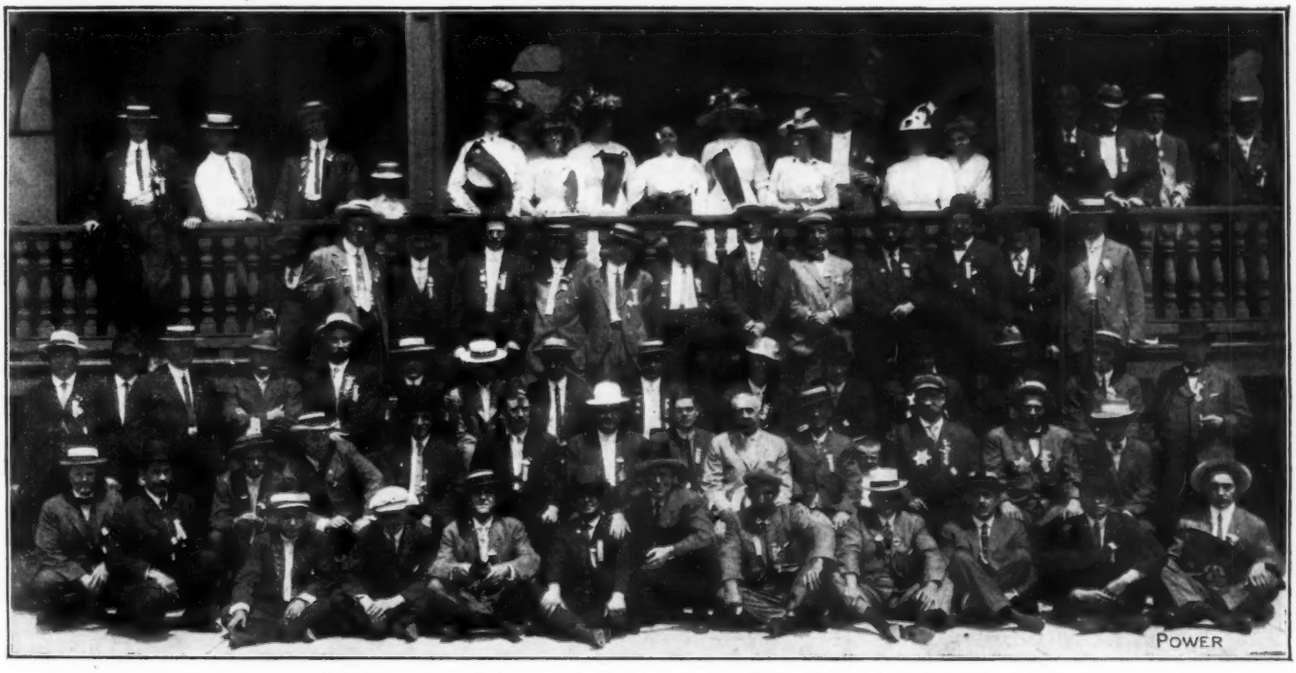
Election of Officers

Joseph B. Craine, Duluth, was elected president; H. F. Mueller, Minneapolis, vice-president; Secretary James McGeary, St. Paul, was reëlected, as was Treasurer J. Albert Johnson; Ivan Frator, Markato, conductor; James F. McCoy, doorkeeper. Fred Kellerhals, John McIver, and William Eldred, trustees, to serve three, two and one years, respectively. The convention recommended T. S. F. Hayes as state deputy.

The entertainment Friday was a sail down the Mississippi River to Homer, Minn., to visit the government fish hatcheries. In the evening the delegates, ladies and visitors were the guests of the Central States Exhibitors' Association at a banquet and "booster" meeting, held in the parlors of the Hotel Winona. The national and state officers were present and made short addresses.

On Saturday, all unfinished business was concluded, the report of the credentials committee was read and the mayor and merchants of Winona were thanked for their hospitality. Duluth was chosen as the meeting place of the 1913 convention.

The big social feature of the convention was the industrial parade. Winona responded by turning out part of the fire department, the street-sprinkling wagons, and all the members of the city council were in the parade. The Pioneer Traction Co. paraded several automobiles and traction engines which created considerable interest. Thousands of people lined the streets as the long procession swept by.



Members and Visitors Attending the Minnesota Convention

The Exhibitors

An excellent showing was made by the Central States Exhibitors' Association, and no detail for the entertainment of the delegates was overlooked. The following members exhibited:

American Steam Gauge & Valve Mfg. Co., V. D. Anderson Co., Crandall Packing Co., Dearborn Drug & Chemical Works, Garlock Packing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Hills, McCanna Co., Home Rubber Co., Jenkins Brothers, H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., Osborne Valve & Joint Co., William Powell & Co., POWER, Schaeffer & Budenberg Manufacturing Co., C. E. Squires Co., United States Graphite Co., Quaker City Rubber Co., Western Supply Co., Crane & Ordway Co., Robinson, Cary & Sands Co., R. B. Whitacre & Co., Viscosity Oil Co., Kunz Oil Co., W. S. Nott & Co., Enterprise Machine Co., Bryan-Marsh Co., William Bros Boiler Works, Hanks Price, Yale & Towne Manufacturing Co., Lyons Boiler Works, Norgaard Soap Co., J. Sherman & Sons, H. C. Witt, T. J. Green, Winona Boiler Works, Standard Oil Co., R. D. Cone Co., A. M. Ramer Candy Co., Union Fibre Co.

Power Company Wins

In the appeal of the Toronto & Niagara Power Co., to the Privy Council, at London, England, the Judiciary Committee has reversed the judgment of the Court of Appeals of Toronto. The Council finds that the company is entitled to erect poles and string wires along the streets of North Toronto for power distribution without the consent of the city corporation.

The company recently decided to devote $3,000,000 to extensions of its system at Niagara Falls, making its total capacity 125,000 hp.

The proposition over which the interested parties came into conflict was the erection of an 85,000-volt transmission line from Niagara to Toronto.

Canadian Stationary Engineers' Convention

On July 23, 24 and 25, at Belleville, Ont., was held the twenty-third annual convention of the Canadian Association of Stationary Engineers. The headquarters were at the Hotel Quinte, and the business sessions were held in the council chamber of the City Hall. There were many visiting engineers and guests and their ladies. In the main auditorium was the exhibits display, and the decorations were tastefully and effectively arranged.

Executive President William Norris presided over the opening session on Tuesday morning, and Mayor Vermilyea welcomed the convention to Belleville, A. M. Wickens and W A. Crockett responding. The association adjourned until 2 o'clock, after the usual announcements and the appointment of committees.

The several business sessions disposed of the work of the convention rapidly and harmoniously. Official reports showed the organization to be in a healthy financial condition, and that the prospects for further increasing the membership and strengthening the influence with manufacturers and superintendents were better than ever before in its history.

A visit was made on Tuesday morning to Belleville's steel plant. On Tuesday evening, accompanied by several distinguished government officials and other guests, the delegates enjoyed a moonlight sail on Quinte Bay. An excellent dinner was served on board, followed by a most enjoyable entertainment.

Wednesday morning the ladies were given an automobile ride through Belleville, and in the afternoon the members and ladies went to Victoria Park to witness the outdoor sports provided. A smoker and general good time were given in the exhibition hall in the evening.

ELECTION OF OFFICERS

At the closing session on Thursday afternoon, the following officers were elected for the ensuing year: William Norris, past president; J. A. Robertson, president; C. Cosford, vice-president; A. Kastello, secretary; W. E. Archer, treasurer; F. Chesher, conductor; H. L. Bishop, doorkeeper.

The Canadian Exhibitors' Association elected the following officers: J. E. Fiddes, president; E. A. Wilkinson, first vice-president; B. M. Walthall, second vice-president; H. V. Tyrrell, treasurer; J. N. Charles, assistant treasurer; G. C. Keith, secretary; C. F. Heatherington, chairman of exhibits; C. P. Archibald, chairman of entertainment committee; C. F. Heitzmann, chairman of reception committee.

On Wednesday morning, the Ladies Auxiliary elected these officers: Mrs. A. M. Wickens, past president; Mrs. W. A. Crockett, president; Mrs. F. H. Chesher, vice-president; Mrs. A. Kastello, secretary; Mrs. C. J. Peppin, treasurer; Mrs. S. Cosford, conductor; Mrs. William Cook, doorkeeper.

During the convention, W. A. Crockett and A. M. Wickens were presented jewels, and William Cook was given a clock. The 1913 convention will be held at Owen Sound.

DELEGATES AND GUESTS AT THE CANADIAN ENGINEERS' CONVENTION

EXHIBITORS

Jenkins Bros., H. W. Johns-Manville Co., Goldie & McCulloch, Dart Union Co., Garlock Packing Co., the Lunkenheimer Co., POWER, Canadian Steam Boiler Equipment Co., *The Power House*,

H. L. Peiler & Co., Dunlop Tire & Rubber Goods Co., *The Canadian Manufacturer,* Chicago Surface Co., Greene, Tweed & Co., Canadian Morehead Trap Co., Peerless Rubber Manufacturing Co., Canadian Fairbanks Co., James Morrison Brass Manufacturing Co., Quaker City Rubber Co., Trill Indicator Co., F. Reddaway & Co., Boiler Repair & Grate Bar Co., S. F. Bowser & Co., Joseph Dixon Crucible Co.

Wisconsin N. A. S. E. Convention

The twelfth annual convention of the Wisconsin State Association of the National Association of Stationary Engineers was held in Racine, July 25 to 28. On Thursday evening, at 7 o'clock, the exhibition hall was officially opened by Robert E. Hills, chairman of the executive committee of the Central States Exhibitors Association. John F. Chapman, chairman of the local committee, introduced Prof. Pressinger, of Marquette University, Milwaukee, who lectured on power-plant testing. The most important item in the cost of operating the average plant, said the speaker, is the fuel bill; hence, it is essential to high economy that the proper grade of coal be selected to suit the conditions of each plant. He described how a proximate coal analysis is made and heat value is estimated by a fuel calorimeter. Stereoscopic views of several types of calorimeter were shown and the construction and operation of each type described. Flue-gas analysis, pyrometry and steam calorimetry were also discussed and boiler tests considered.

H. J. Mistele, chief engineer of the Falk Co., Milwaukee, in a highly interesting paper on power-plant costs, showed that all that is absolutely necessary in conducting a boiler test to approximate the cost of evaporation is the ordinary scales found in the average plant, and a thermometer reading to 400 or 500 deg. If a feed-water meter or an extra pair of scales is not available, or if the arrangement of the plant is such that the feed water cannot be weighed, then the feed pump can be "calibrated" by weighing its discharge for a given number of strokes when running at about the speed required under normal conditions, to feed the boiler to be tested. While one thermometer is essential to find the temperature of the feed water, a second is desirable to ascertain the quality of the steam being delivered. The speaker also showed how simple it is to measure the work being done by the engine by means of the indicator and from this and the boiler test to figure the cost per unit of output.

At the Friday morning session, Mr. Chapman introduced Mayor W. S. Goodland, who delivered the address of welcome. National Vice-President John F. McGrath in his response spoke of the birth and growth of the National Association of Stationary Engineers, and what it has accomplished.

President G. H. Wallace, of Racine No. 3, welcomed the delegates to Racine, where the state organization was formed 12 years ago. State President William Classmann told of the increasing interest taken in the state body and of its growing importance in the affairs of the association.

National Secretary Fred Raven spoke of the beneficial effects of the mechanical exhibit, now a feature of the state and national annual meetings, serving as it does, to arouse interest and attract a greater attendance.

John W. Lane, editor of the *National Engineer,* spoke of the engineer's lack of a knowledge of the value of publicity and its effect on his welfare and success, and Secretary W. L. Osborne, of the Central States Exhibitors Association, spoke briefly on the exhibit and its purpose.

State President Classmann in his opening address advocated a systematic educational program to be participated in by all the associations in the state, each association to compile and forward to the state secretary a limited number of questions relating to power-plant operation, the secretary to have them printed and distributed to all the subordinate associations for discussion and answers. He also recommended making the duration of future state conventions one day longer because of the increasing business coming up each year. After the appointment of the committee, the meeting adjourned until 1 p.m.

At the afternoon session the following committee reports were received: credentials, auditing and ways and means, the latter reporting favorably on both of the president's recommendations.

The recommendation to extend the time of the convention was voted down on the ground that it might work a hardship to many who could not spare the time and because of the additional expense to the exhibitors. The educational program was favorably considered and a committee appointed to work out the details.

After the session the J. I. Case Co. and the Mitchell-Lewis Motor Co. plants were visited. At 7 o'clock, E. W. Pfleger, of the General Welding & Manufacturing Co., Milwaukee, lectured on "The Application of Welding in Manufacturing and Repair Work." In the evening, the delegates and visitors attended the New Orpheum Theater and saw "The Show Girl."

At the Saturday morning session, Walter Krueger lectured on "Refrigeration" and Reinhart Kunz spoke on "Engineer's License Legislation."

H. S. Bowers presented a paper at the afternoon session on "Factory Heating and Ventilation" and Fred Ruck lectured on "Power Plant Records." The following officers were elected: H. J. Mistele, president; A. Gunderson, vice-president; Robert Fenn, secretary, reëlected; A. Pfaller, treasurer; J. Jensen, doorkeeper; G. H. Wallace, conductor; John Wickert, state deputy.

In the evening, the Central States Exhibitors' Association gave a complimentary smoker in the Hotel Racine dining room, at which many appropriate and witty speeches were made. Among the speakers were Fred W. Raven, John W. Lane, John Wickert, William Classmann, G. W. Wallace, C. H. Fiske, Thomas McNeil, H. J. Mistele, C. W. Naylor and Robert Fenn. W. L. Osborne was presented a gold watch and fob by the association in recognition of his work during the past year, the presentation speech being made by Fred Raven. Fred Hickey, of the Dearborn Drug & Chemical Works, sang several solos, and the entire company united in many popular songs.

On Sunday morning baseball teams composed of the engineers and the supplymen competed for a silver punch bowl donated by H. S. Bowers. After a close contest the supplymen won by a score of 15 to 14. In the afternoon, a reunion was held in Central Park at which many old acquaintances were renewed and new ones formed.

The Central States Exhibitors' Association at its business meeting on Saturday afternoon elected W. L. Osborne president and Charles Cullen secretary for the coming year.

Exhibitors

The mechanical exhibit, held in the Hotel Racine, was unusually large and interesting. There were displays by the following members:

Lunkenheimer Co., Greene, Tweed & Co., Dearborn Drug & Chemical Works, William Powell Co., Hills, McCanna Co., Hawk-Eye Compound Co., American Steam Gauge & Valve Manufacturing Co., Keystone Lubricating Co., Garlock Packing Co., Schaeffer & Budenberg Manufacturing Co., V. D. Anderson Co., Jenkins Brothers, POWER, Osborne Valve & Joint Co., C. E. Squires Co., Home Rubber Co., Crandall Packing Co., J. H. Johns-Manville Co., United States Graphite Co., Lyons Boiler Works, White Star Refining Co., Viscosity Oil Co., Foster Lockwood Oil Co., Vilter Manufacturing Co., Julius Andrae Co., Perfection Heater & Purifier Co., Richardson-Phoenix Lubricator Co., O. L. Packard Machinery Co., George B. Carpenter & Co., F. Sprinkmann & Sons, Racine Electric Co., Chicago Rubber Co., S. Freeman Sons Manufacturing Co., Falls Machine Co.

The Casualty Company of America has given up boiler and flywheel insurance, its outstanding risks being reinsured by the Hartford Steam Boiler Inspection & Insurance Co.

Consults Employees Before Buying

For years it has been customary for the buyer of an engineering concern before purchasing supplies to send a note asking the opinion of all department heads, foremen and even the higher skilled employees, who usually know what is most needed.

Often, says *System,* he has been able thus to secure very valuable advice in getting the right goods at the right prices. If this procedure were more often followed before purchasing power-plant supplies, and the engineer's requisition more rigidly adhered to, conditions in both the office and the plant would be much improved.

Old Plant Again in Service

On July 22 the work of overhauling the old auxiliary steam plant of the Toronto Ry. Co., on Frederick St., Toronto, was completed. With the steam reserve plant of the Toronto Electric Light Co., it will be kept running continuously until the Electrical Development Co.'s new transmission line from Niagara is ready for service.

The old plant has not been in use for four or five years, but now that it is put in order, it is capable of generating the full rated capacity, 7000 hp., the same as the Toronto Electric Light Co.'s plant.

Receiver for Atlas Engine Works

Fred C. Gardner, treasurer of E. C. Atkins & Co., has been appointed receiver of the Atlas Engine Works, of Indianapolis, Ind. The application was made to the superior court by F. H. Wheeler and G. M. Schebler, creditors in the sum of $2387.50.

A Great Power Project

According to press reports, a mammoth combination of central Illinois mining interests is about to be effected. Francis S. Peabody, of Chicago, is behind the proposed merger. The purposes involved are a merger of all coal interests and companies in central Illinois, the erection of a big power plant at Kincaid, from which current will be taken for operating all the Commonwealth electric properties, including those in Chicago, and a merger of all or nearly all the public-service plants in the state.

It is said that Mr. Peabody is acting for the Commonwealth Edison Co., of Chicago, which has a capital of $40,000,000. The disclosure of the plan came with Mr. Peabody's purchase of the public utilities at Taylorville, Nokomis, Edinburg, Pawnee and other towns in Christian County. He has options on all but three of the 70 coal mines in Sangamon, Christian and Montgomery counties.

Engineers for the company have selected the Kincaid site for the power plant because of the availability of water. The plan includes building a power transmission line from Kincaid to Chicago. Editorial reference has been made to this project on page 196.

New Plant on Savannah River

The Georgia-Carolina Power Co. will build a hydro-electric power plant at Stevens Creek, on the Savannah River, nine miles from Augusta, Ga. At this point the river is about 2700 ft. wide and forms the boundary between Georgia and South Carolina.

The power house, about 360 ft. long, will be at the Georgia end of the 2300-ft. dam. The spillway section will be about 2000 ft. long and contain five waste gates about 5 ft. square. The average height of the dam will be 34 ft. Flash boards 3 to 4 ft. high are to be provided.

Ultimately the installation will be 18,000 kw. in ten main units, with two 200-kw. waterwheel-driven exciter units and one 200-kw. motor-driven exciter. The average head will be 27.3 ft. with extremes of 16 ft. and 32 ft. At present the installation will include five main and two exciter units.

Transmission lines will be constructed to Augusta, Ga., 10 miles, and from Augusta to Graniteville, S. C., 17 miles, making a total of 27 miles, to be operated at 33,000 volts. The generation voltage will be 2300. This work will be completed early in 1914 and the cost will be about $2,500,000.

Motors for Collier "Jupiter"

The two motors for the collier "Jupiter," now being built at the Mare Island Navy Yard, at San Francisco, were tested at the General Electric Works recently in the presence of navy and shipbuilding officials. The scheme of propelling vessels of large size with big electric motors as developed by W. L. R. Emmet, of the General Electric Co., makes possible simple control, direct from the bridge or wheelhouse, to regulate the speed forward or reverse, or stop. The turbine, generator and motors will be shipped within two months.

SOCIETY NOTES

The American Society of Heating and Ventilating Engineers announces the election of 18 full members, five associate members and three junior members.

The Verein Deutscher Ingenieure have invited the American Society of Mechanical Engineers to attend their next annual meeting in Leipzig on June 23 to 25, 1913, and the invitation has been accepted by the Council. A committee of arrangements will shortly be appointed and the society can expect an extraordinary opportunity to hold a meeting with the National Society of Germany, to make an official tour of the industrial centers, concluding with a meeting in Munich and a visit to the German Museum, of which Dr. von Miller, the president of the German Society, is also president.

PERSONAL

Waller Edwards has been appointed publicity manager of the Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo., succeeding A. O. Krieger, resigned.

Charles F. Uebelacker, Charles N. Black and William von Phul have been admitted to partnership in the engineering firm of Ford, Bacon & Davis, New York City.

P. W. Sothman, chief engineer of the Toronto Hydro-Electric Power Commission, will resign on Sept. 1. He will probably be retained as consulting engineer by the commission.

Charles M. Rogers is superintendent of generation for the Empire District Electric Co., Joplin, Mo. The reference to his recent appointment as combustion engineer for that company in the issue of July 16, was an error.

Nelson S. Thompson, chief mechanical and electrical engineer in the Treasury Department, will represent the American Society of Heating and Ventilating Engineers at the fifteenth International Congress on Hygiene and Demography at Washington, D. C., Sept. 23 to 28.

R. M. Harding, superintendent of lighting of the Pensacola (Fla.) Electric Co., has been appointed general superintendent of the Columbus (Ga.) Electric Co., which controls and operates the Columbus R.R., the Columbus Power Co. and the Gas Light Co. of Columbus.

Robert L. Brunet, of the Public Service Corporation of New Jersey and formerly with the General Electric Co., has been appointed city electrical and gas engineer of Providence, R. I. Mr. Brunet is a graduate of Union College and 27 years old. He will take up his new duties very shortly.

Charles F. Gray, formerly superintendent of construction for the Canadian Westinghouse Co., and chief erection engineer in charge of the installation of the company's apparatus for Winnipeg's municipal hydro-electric system, has opened a consulting electrical engineering office in Empress Block, Winnipeg. Mr. Gray had had 15 years' experience in engineering and construction work in many of Canada's hydro-electric developments, as well as in several of the large central stations in New York.